Awareness in the Inductive Solution of Problems Using Words as Stimuli

BY
COLIN J. HERRICK, PH.D.

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CHAPTER I

INTRODUCTION

The experiments reported below are aimed at two questions involving inductive learning in the verbal field. First, can there be effective learning with verbal materials when the learner is unaware of what he is learning? Second, what is the course of such learning, especially with reference to the number and variety of hypotheses tried, the methods used in testing them, and success in applying a correct hypothesis?

The primary question is one which has received some little experimental attention, leading to the conclusion in at least one case that such learning can take place not only "without awareness of what is being learned" but even without the "intent to learn it" (21). Such a conclusion, if it be accepted, is so important in its implications for applied psychology as to call for the most careful verification.

A series of six experiments was therefore set up with the intent to investigate, as broadly as possible within the limits of a single type of stimulus material, the relationship of awareness to learning. Introspective reports were written by the Ss. in the course of each experiment. Each experiment contained a problem to be solved, with the statement of the solution taken as the criterion of learning. The stimuli in each case were isolated words. Each experiment began either with free association responses, or with responses by numbers assigned by the Ss. As learning progressed, each experiment became one in controlled association, with responses controlled by a principle derived inductively through generalizing on successes and failures as announced by the experimenter. The correct principles were as follows:

Verbal responses, the response word to be,—

1. One which normally follows the stimulus in connected discourse. (This is the same principle as was used by Thorndike and Rock, 21.)
2. Given within 1.4 seconds after the stimulus.
3. A match for the stimulus in rhythmical pattern.

Numerical responses, the numbers to classify the stimuli as to,—

4. Part of speech.
5. Number of vowels.
6. Frequency of use in written English.

Language sequence, speed, rhythm, grammatical use, spelling, and familiarity,—the general fields into which these problems fall sample widely the ways in which adult subjects have been accustomed to responding to words. Each principle is simple, and all but the first and sixth are easy to apply, once they have been learned. And although we should expect the solutions to differ according to the previous experience and linguistic habits of the subjects, the situation and the stimulus material are roughly similar in all the problems.

CHAPTER II

REVIEW OF THE LITERATURE

The free association method is an old one in experimental psychology; representative early reports are those of Galton (5), and of Cattell and Bryant (2). Once the method had been developed, it was apparent that it was a promising one for the investigation of emotions, and the attempt was soon made to apply it to practical situations, notably in psychiatry and crime detection. Jung's work (9, 10, 11) may be taken as typical of the psychiatric use of the association method. Through an extended period a good deal of effort was put on the validation and application of various association word tests. But although the purpose and emphasis were different, some of these earlier studies are pertinent in the present connection.

Wells reported in 1911 on the effects of practice on free association (22). Using six Ss., and timing their responses to the nearest fifth of a second, Wells presented 50 words daily, six days a week, until free association responses had been obtained to 1100 words. There were 1000 different words; the eleventh hundred was a repetition of the first. He could thus compare responses to the same words, before and after practice on 900 others.

The responses were classified into three main types; emotional, intellectual, and superficial. These types, in turn, were subdivided into 18 classes, according to a system used by Jung. Two of these classes, both of the "superficial" type, are important here: the speech motor response, and the word completing or word compounding response. Both of these would be considered, within the meaning of the present series of experiments, as showing a tendency to follow the sequential patterns of speech and writing. From a somewhat later paper (23), presenting a simplified classification into five types of response, it is apparent that some responses classified otherwise by him might reasonably be classified as falling in the same sequential pattern, *e.g., crooked–line, invent–machine, never–decide.*

Important conclusions from this experiment were that extended practice in free association reduces the reaction time to approximately 1.2″, that it makes the responses of less significance, and that it makes them on the whole more superficial.

On the first presentation of the 100 test words, Wells classified

17 of the 599 responses as being of the two speech categories mentioned above; after practice the number increased threefold to 53. Examples of such shifts follow, with the reaction times in fifths of a second put after each response word:

Stimulus	*First Response*		*Second Response*	
axle	hub	11	grease	6
pancake	tough	12	flour	9
spread	distance	17	bed	7
suffer	weak	11	pain	4
virtue	good	18	reward	7
heaven	peace	18	hell	7
herald	king	8	globe	7

There are several interesting questions about such changes in reaction words and reaction times. First, do they represent learning? Almost certainly not, if we consider learning to lie in the establishment in the learner of behavior patterns not previously present. These changes do, however, show improved performance along certain lines,—a type of improved performance which is often called learning. The question then arises, along what lines? Was the development in the greater use of purely linguistic habits, with greater speed of response as a by-product, or was it toward greater speed, with the change in type of response incidental to the change in speed? Or was the development towards simplicty and superficiality, and away from the emotional and intellectual type of response, as Wells suggests? In brief, if we care to call the changed performance learning, *what* was learned? From the objective record alone, without the benefit of introspections, we can only say that several things were learned, and that these types of response are probably so related that improvement in any one of them will involve improvement in all. But since Wells reports no introspections, this conclusion is a mere conjecture.

Finally, it is significant to inquire whether Wells' Ss. had any intent to learn, and whether they were aware of such learning as may have taken place. Again, failing any introspections, no clear-cut answer is possible. There is certainly less reason, *a priori,* to assume awareness and intent in this experiment, in which there were no announcements of *right* and *wrong,* and in which no cash prizes were offered for speed and correctness of response, than in certain of the later experiments aimed specifically at investigating the possibility of learning without awareness. But in view of other evidence, to be presented later, there is little reason to suppose that

Wells' Ss. were unaware of the direction of the changes in their responses, whatever their intent may have been.

The Kent-Rosanoff study, published in 1910, is probably the most widely known of the free association studies (13). It reports the standardization, on 1000 normal people of various ages and degrees of education, of the Kent-Rosanoff test, which has been used in psychiatric diagnosis. The person tested responds by free association to a list of 100 words; in using the test the psychiatrist considers the frequency and nature of the deviations from the established normal responses. Later studies extended the standardization to children's responses (14, 26).

For our purposes, the significant thing about the work with the Kent-Rosanoff test is the community of reaction shown by normal people. Examination of the stimulus list explains this in part. The authors set up as criteria for the stimuli that they: should not be personal in the associations evoked; should be unrelated to each other; should not be peculiar to any temperamental, environmental, or other purely individual aspects of the subject's experience. In brief, the requirement is that every stimulus shall, so far as possible, mean the same thing to every normal subject. In view of the purpose of the test, the criteria were excellent, and the obtained community of response is an index of how well the words were chosen. If variation of response is to be interpreted as indicating emotional variation, the purely intellectual aspects of the stimuli must be held constant; the results obtained by Kent and Rosanoff from their normal group show that such control could be exercised reasonably well, even without the aid of the numerous vocabulary studies which have come out since 1910.[1]

In this connection it is significant that Kelley, when he reported in 1913 on the correlation of association reactions with essentially intellectual criteria (12), used a stimulus list which he characterized as containing a high proportion of abstract words; his stimulus list proves now to have a high proportion of words of relatively infrequent use. There is, naturally, an overlap between abstractness and frequency of use, but the latter criterion is more easily subjected to exact, quantitative treatment.[1]

The next study to be reported includes an attempt at experimental variation of the intellectual aspects of the stimuli, under-

[1] *Cf.* pp. 24 ff., The Stimulus Lists. In a projected later paper the stimulus lists used in various of the early free association studies will be matched against some of the frequency lists of word usage based on the more recent vocabulary studies.

taken so that the meaning might be held constant in a test situation. Crane presented in 1915 the results of a comprehensive study of reactions obtained by the free association method (3). He was undertaking to validate a test procedure by which he might use reaction times in free association as indices of the presence of "guilty knowledge." (*Cf.* also Yerkes and Berry, 27.) This use of the association word method in crime detection is a special case of its use in studying the emotions.

In Crane's work the stimulus words were presented visually, and the reaction times measured by a Hipp chronoscope. He used 20 Ss., and asked them for explanatory introspections after each "markedly delayed" response. Crane studied a number of factors which might influence reaction time in a free association response. Especially important were those relating to the grammatical use of both stimulus and response words. Which part of speech has the longest reaction time? With a given stimulus word, which part of speech has the longest reaction time? How are stimulus and response commonly related with respect to verbal form? What is the effect when successive stimuli are words commonly paired by a conjunction? How will the presence of a series of stimuli, each usable only as a single part of speech, or with a single meaning, affect the responses to a succeeding "indefinite" or "ambiguous" stimulus, of the type *boil* or *fast*?

He found that the modifier stimuli, adjectives and adverbs, gave the shortest reaction times, verbs the longest, and the nouns were intermediate. Further, he noted the frequency of response words which would normally follow their stimuli in speech. He noted, too, that every S. treated at least 1 of the 50 noun stimuli as an adjective, and that the number of such treatments ran as high as 19, *e.g., brick–wall, apple–pie.*

After considering in his discussion the types of association which stimuli of each type might be expected to arouse, Crane says:

> "It would naturally appear that the word to be responded to any stimulus would be the one that would most naturally and logically follow after the stimulus word. We are continually expressing ourselves in speech and in writing. Even our unexpressed thoughts tend to be carried on in verbal form. In all our use of language there is a natural sequence, probably of thought, and quite clearly of language." (3, p. 17.)

His analysis of the psychological processes underlying the association word reaction is so apt that I shall quote from it at some length.

> "The noun, ordinarily, is concrete, an entity. If the stimulus man is given, the subject immediately gets a complete idea—man. It may be a given man in

a given situation, man in general, some particular type of man. Whichever it is, it is complete, it is a whole. What is the subject going to reply? He may reply with a descriptive term, or he may reply with some other part associated in this entity. Whatever he replies he must move away from his completeness to do it. This means a choosing from among possible replies, an effort to pick out some one. Moving away from completeness also means unpleasantness. All these factors naturally tend to lessen the probability of any natural sequence of verbal order being evidenced in the response which finally comes. Likewise these same factors tend to lengthen the reaction time.

"The modifier, on the other hand, is the exact opposite of the noun. It is incomplete. It means nothing of itself. When the modifier stimulus appears, because of the incompleteness there is unpleasantness until the reaction takes place and completeness ensues. Thus the very incompleteness of the modifier is a goad to action. Moreover, the very same action that removes the incompleteness, at the same time usually supplies the necessary reaction word. The word dark, of itself, has no sufficient meaning, but dark something has. It is the something that makes the meaning and the completeness. At the same time it is the something that furnishes the reaction. This means the persistence of the natural linguistic sequence in the reaction word. And as a result of these things comes, of course, a shortened reaction time." (3, p. 19.)

Had Crane been writing a few years later he would probably have written in terms of the law of closure. The terminology, however, and the theory, are of far less importance in this treatment than the facts as to the responses and the reasons assigned for them. This is hardly the place to quote Crane's protocols; but the interested reader may verify for himself (3, pp. 20–34 *passim*) not only how frequently the "natural linguistic sequence" is involved in the responses, but how conscious the Ss. were of this tendency, often seeming to take it as understood that preservation of this sequence was the one normal principle determining their responses.

The two studies by Wells and Crane are useful on the score of method, showing as they do how we may expect free association responses to be affected by extended practice, and by the make-up of the list of stimulus words. The studies which apply this method specifically to the problem of awareness in learning are more recent.

Thorndike, in a series of lectures published in 1931, refers several times to learning without awareness. He says, for example (16, pp. 76–77):

"In each of these experiments, there is, in addition to the connections which the subject tries to make and knows he is making, a second connection or set of connections which the subject does not try to make, since in fact he does not know what they are or even, in most cases, that there are any such. . . .

"The experiments are somewhat delicate to devise and operate, because if the second sort of learning is not well hidden, the subjects will become aware

of it. Also if it is carried on to a point where these connections acquire much strength, they may thereby force awareness of themselves. What begins as a direct unconscious strengthening of a connection by its satisfying after-effects may grow into a habit that attracts the subject's attention and then blossoms into a rule of action supported by a judgment.

"When this latter happens, the experiment as a whole is spoiled so far as concerns its value as a crucial test of the direct potency of the after-effects of a connection. But it may become a valuable experiment to show that insights not only produce and guide habits but are also produced by them."

These same experiments were reported in more detail by Thorndike in 1932 in his *Fundamentals of Learning* (15). Experiments 86 and 87, in the chapter on "The Influence of Mental Systems," and Experiments 99 and 100, reported in Appendix IX, are especially important in the present connection. As a group these experiments investigate on a fairly broad scope the type of responses given under a free association method. Thorndike's discussion of the results gives analytic attention to the individual responses, and is fortified by a review of earlier free association experiments, using the Kent-Rosanoff list.

Unfortunately, however, his chief interest seems to have been in discovering the influence of various systems—sensory, instinctive, customary, and transcendent—to such an extent that he paid little or no attention to two aspects of the stimuli which are probably of great importance in determining responses under a free association method: the grammatical classification of the words, and their frequency of use by the subjects. The first of these is easily subject to experimental control. The second is more difficult to control, but not unduly so in view of the excellent frequency lists now available.

His findings in the main were that generalized or special habits and habit systems can convincingly explain most of the obtained responses. Certain of his statements are worth quoting exactly, as providing a background not only for his later work with Rock, but for the experiments reported below.

"Sixth, if we present the stimulus word, not in isolation but after some rather colorless word like *the* or *his* or *with*, the number of responses by opposites is lessened decidedly. If we present it in phrases or sentences like *in the sweet, and very cold, he is slow, how beautiful* or *in that rough,* and require that the first two words which come to mind be written, the number of responses by opposites is reduced to almost zero." (15, p. 367.)

"The facts are then as follows: A word alone calls up its frequent and fit sequent in speaking and writing if there is such a one strongly connected with it. If there is not, it follows the lead of the word-meaning connections and calls up

some word which they produce. When the word is prefaced by *the, a, his, our, that, sharp, very, in,* and the like, the speaking-writing connections become somewhat stronger. . . ." (15, p. 602.)

These experiments were admittedly suggestive rather than definitive, but they accomplished two important things. They provided the basis for Thorndike's explicit statement of the value of the free association method in the experimental attack on problems involving intellectual activity. After years during which the method had been used largely for investigating the emotions, this emphasis on the broader purposes it might serve has been very healthy. Second, these experiments confirmed adequately what had already been apparent in the work of Crane and others: that the speech-writing sequence is a very common one under conditions of free association, and that the degree of community shown by this sequence can be controlled by appropriate variations of the form of the stimulus.

With this background we are ready to consider critically two similar experiments using a free association method to investigate learning without awareness.

Thorndike and *Rock* reported one such experiment in a 1934 paper (21). Records are presented from 30 Ss., who responded singly to "320 or 640" words with the first word or words that came to mind. Reaction times were taken, and a money prize was promised for (average) speed of response. Another important feature of the stimulus situation is best quoted from the instructions:

"Also I shall say 'Right' if the word that you say is one of ten or more that we have arbitrarily decided to call right as responses to the word in question. I shall say 'Wrong' if the word that you say is one of ten or more that we have arbitrarily decided to call wrong as responses to the word in question. Sometimes I shall say nothing because the word that you say is in neither our list of Rights nor our list of Wrongs for the word in question."

Right was announced if the response was "clearly due to the sequential connections used in speaking and writing"; *Wrong* if to "connections used in getting the word's meaning." No announcement was made to the S. in cases where the experimenter could not immediately decide which of the tendencies was operative. Certain conventional deviations from the above system were followed in announcing Right and Wrong to the Ss., in order to prevent any marked improvement in their scores due to their following consciously some system other than the right one, *e.g.*, conscious avoidance of opposites. The responses were checked later, however, counting as right all responses which seemed "probably due to the speech-writing sort of connections."

This experiment is less happy in conception than some of those by Thorndike which preceded it; further, it is open to question both on the score of treatment of results and of interpretation. The treatment involves a number of assumptions which are not only unsupported but which seem in the light of other evidence to be unreasonable, outstanding among which are the two in the title.

The first important criticism springs from analysis of the results presented in Table 2 (21, p. 12). The fact that the total of correct responses in the first forty words was 358, and that this rose to 720 in the last forty words does indicate learning. But it indicates unequal degrees of learning for the two groups of Ss. used, who differed in the order in which the stimulus words were presented. With a list of 320 words divided into quarters, the first 14 Ss. received the four quarters in the order 1, 2, 3, 4, and the last 16 Ss. in the order 4, 3, 2, 1. Such an arrangement is a good one, providing as it does a chance to estimate the stimulus value of the words independent of such effects as might derive from their serial positions. But having devised the check, the authors seem not to have used it.

The first group of Ss. increased their total number of right from 174 to 407, a gain of 134 percent. The second group, with changed order of the stimuli, increased from 184 to 313, a gain of 70 percent. Fuller data about these two groups, drawn from the same published table, are presented graphically in Fig. 1. Group 1 had a better performance after 20 stimulus words than Group 2 after the first 80. Group 1 had reached by the 70th presentation a level which was not reached by Group 2 until the 300th. Granting that both groups learned, the difference in learning is so marked that we are justified in seeking some explanation in the make-up of the list of stimulus words. But since Thorndike and Rock report only that their Ss. responded to 320 or 640 words, give their statement of the order of the presentation as though each S. had responded to the same 320 words, and present their tabulated results in a form which implies that the last word responded to was the 300th, it is not profitable to undertake the necessary analysis of their stimulus list.

A second major criticism is of the use of a sudden rise in the proportion of correct answers as the only criterion of awareness. This issue was adequately handled in a corroborative experiment by *Irwin, Kauffman, Prior,* and *Weaver* (8). These authors repeated the experiment of Thorndike and Rock, but with two important modifications of procedure. At various points in the experiment

their Ss. were specifically instructed in the principle underlying the assignment of Right and Wrong, and then run on through a further series of test words. In addition, 7 of the 12 Ss. were given a final trial of 20 words, with instructions to take as much time as they needed in order to get their responses right. The evidence that learning with this material is gradual even after specific instruction was quite clear from this experiment. Thorndike and Rock (20) admitted that the criterion of gradualness had been ill-chosen, but reaffirmed, in the main, their original conclusions.

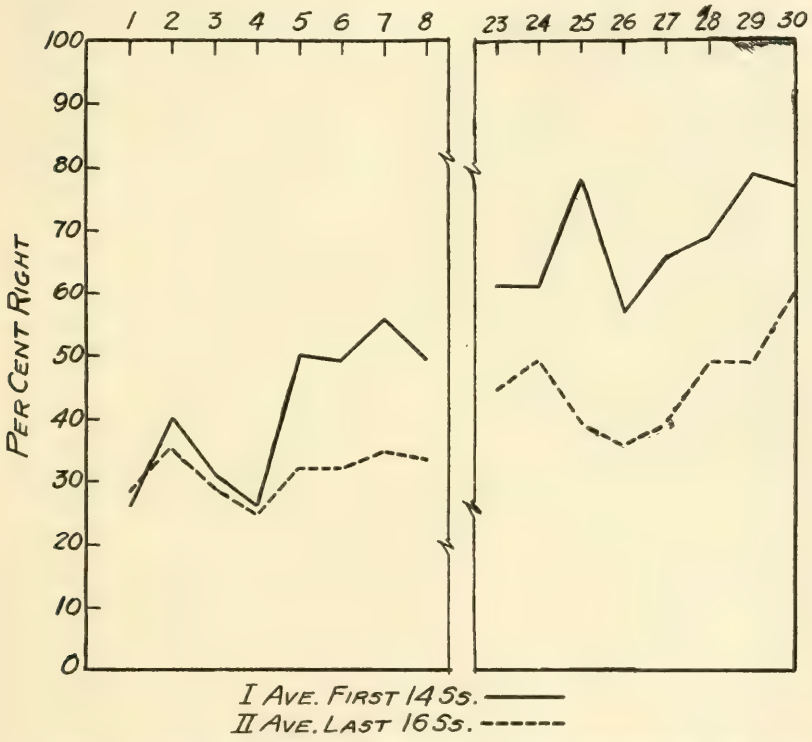

FIG. 1. From Thorndike and Rock, Table 2—first eight 10's and last eight 10's. Group I did the four quarters of the word list in order 1, 2, 3, 4. Group II did the quarters in opposite order—4, 3, 2, 1.

The implications of Thorndike's and Rock's title, " . . . without . . . intent to learn it" remains merely an implication, with no supporting experimental evidence. An equally reasonable, but opposed, inference from the two types of reward offered by their instructions would be that their Ss. probably had a strong intent to learn.

The crux of these criticisms of the experiments by Thorndike and Rock—and they are necessarily sharp—is one of general method. The attempt to use purely objective criteria in an experiment dealing with awareness and intent, leads the authors through a series of statements such as the following: "If he thinks about the experiment at all, he probably thinks of it as a test of his sanity, or complexes, or interests, or speed of reaction, or expects the same words to recur. If he did anything voluntarily, he might. . . ." (21, p. 3.) From this point we advance through conjecture to the following statement:

> "It is our opinion that if (those subjects who did not learn) had done the experiment naively, without trying to appear intelligent, or to make a good impression on the experimenter, or to solve some system which they imagined was back of the choice of 'Rights' and 'Wrongs,' they probably would have learned. If the tendencies that produce a word or words when a word is heard had been allowed to operate undisturbed, the speech-writing tendency would, in our opinion, have been strengthened in all persons in whom it operated at all. But we cannot prove this." (21, pp. 9–11.)

The above review of the literature does not pretend to be comprehensive. The effort has been to show in a general way the type of problem to which the free association method has hitherto been applied, and to examine in more detail certain of the data which it has yielded bearing on the relationship of awareness of learning. The following statements based on this review are put down, not as new or especially profound, but because they define the position of the present experimenter, and provide the ground or context within which the experiments below should be considered.

1. The association word technique can be made useful in the study of intellectual, as well as of emotional processes.

2. When this method is to be used for the study of intellectual processes great value can be derived from introspective reports.

3. Extreme care must be taken to control, or, if that is impossible, to appraise as accurately as may be, the stimulus value of the words presented. Any subject with enough intellect to make him available for such experiments will for years have been receiving words as stimuli, and will have built up an indefinite number of ways of responding to them.

4. If valid generalizations about learning are to be drawn from association word experiments, they should be based on problems sufficiently numerous and varied to ensure that real learning—the acquisition of new types of response—is involved, rather than the mere strengthening of tendencies already well learned.

CHAPTER III

EXPERIMENTAL PROCEDURE

The subjects were six men and two women, ranging in age from 19 to 29. Four of them—C, D, G, and H—were undergraduates, with varying, but in no case extensive, training in psychology. Two of the other Ss., B and F, were graduate students in psychology; A and E were college graduates, both with teaching experience, and the former with business experience as well. Five of the Ss.—B, C, D, E, and F, acted in five experiments each; A, G, and H were used in one, two and two experiments respectively.

The *order of experiments* was different for each of the Ss. who took part in more than one, and so arranged that each experiment was done first by at least one S., and appeared in at least three different serial positions. This order was planned in order to cancel out the possible advantage or interference which might be carried from the experience on one problem to the approach to another. It seemed likely in advance that such factors would be of considerable importance, and this proved to be the case.

Preliminary instructions to the Ss. were as follows:

"There will be several experiments, each one using words as materials, and each one containing some problem to be solved. From time to time in the course of each experiment I shall ask you to introspect in writing about your mental processes while performing the experiment. I prefer not to suggest the type of introspection to make: whatever occurs to *you* is what I want, expressed in your own way rather than in any terms or forms I might set."

Introspections were requested after every 20 responses. Ss. were encouraged to write fully, and on some occasions when they had written vague generalized statements they were asked to be more specific, or to give illustrations. In all such cases the effort was made to refer only to the fullness—the form—of the introspections, without giving hints as to the aptness of the matter. The experimenter read the first introspection on each experiment as it was made, and a large proportion of the others. Some Ss. frequently made oral comments. Those which came within a group of 20 words were noted by the experimenter on his record, if they seemed significant. If they occurred during or after the written introspection, the suggestion was made that they be put in writing. In general the Ss. were encouraged by the attitude that any ideas or comments of theirs were significant, although not necessarily correct.

Assistance was given in a few cases by telling the S. that he could not solve the problem by the method he was using, and in one case by telling the S. that she had some time since been close to the correct solution. Such statements by the experimenter always came immediately after the introspective report; the S. was instructed to write the statement verbatim in his notes, thus avoiding the risk of ambiguity in the record, and ensuring the attention of the S. to the statement. Such assistance was justified by experience with a preliminary experiment similar to the Parts of Speech Experiment in this series. Certain perseverative or opinionated Ss. in this earlier experiment had persisted through several hundred stimulus words, testing out systematically one application after another of the same wrong hypothesis. This continued in one extreme case through 660 words. In this series of experiments, accordingly, when the introspections indicated that such a perseverative tendency was operating, the experimenter tried to save his own time and the good will of the S. by interrupting it; even so, it continued in some cases regardless of specific negative instructions.

Experimental sittings lasted in some cases for as long as two and a half hours, although few of them ran beyond an hour and a half. Several sittings were necessary for each S. who reported on the full series of experiments. In almost every case adjournment was timed to the solution of a problem. In those few instances where fatigue or flagging motivation made it advisable to adjourn leaving a solution incomplete, the S. was urged not to think about the problem in the interval until his next appointment. Just before resuming work in such cases the experimenter read the instructions again to the S., and then read to him all introspections he had made on the problem in question. A quiet room, free of interruptions, was the only special requirement as to surroundings; the Ss. were permitted to walk around while preparing their introspections, to smoke if they cared to, and to be as much at ease as possible. All Ss. responded with good speed through their lists of 20 stimulus words; the time taken for introspections varied widely between Ss. as well as within the performance of a given S.

Announcement was made to the Ss. about the correctness of each response, and of the number of correct responses in each group of 20 words. Except as noted above under the heading *Assistance,* no announcement was made as to the correctness, either partial or complete, of their generalizations.

The *Criterion* of learning was the statement by the S. of the correct principle in the problem. This meant that in several cases

the experiment was stopped before the S. got a perfect quantitative score as well. This had some disadvantages; the experiments had been introduced to the Ss., however, as containing problems to be solved, the problems were very difficult, and as soon as the S. felt sure of his solution there was in most cases so complete a change in motivation that the results of presenting a few additional lists of words could not justifiably have been interpreted on the same basis as the other data.

Conditions common to all experiments have been presented above; those peculiar to the individual experiments will now be stated, reserving the detailed analysis of the stimulus lists until a later section.

I. *The Sequence Experiment* was in most respects a repetition of the procedure used by Thorndike and Rock in their Free Association Experiment mentioned above (21). Instructions for this experiment were drawn, with the necessary modifications, from the instructions which they used:

"I shall say *ready* and then say a word. You are to reply with the first word or words that you think of. I shall say *Right* or *Wrong*, depending on whether your response is on the list of words that I have arbitrarily decided shall be called right or wrong as responses to the word in question. If I say nothing, it will be because your response is not in either list. I shall record the time of each response; at the end of the experiment there will be a money bonus depending on your speed of response, and another depending on credits for *Right*, and penalties for *Wrong* responses.

"After each twenty words I shall tell you how many *Right* responses there were. You will write your introspections after each twenty words, and we shall then pass on to the next group. Please answer quickly, and with enough force to set off the voice key. If you are uncertain of what the stimulus word is, please respond anyway, as best as you can, rather than ask to have it repeated."

Timing was by means of a Dunlap Chronoscope, equipped with voice keys for both E. and S. This is capable of measuring down to 1/1200 of a second,—a much finer measurement than was needed. But the convenience of the voice keys and of the time record made it a desirable instrument. Times were recorded to the nearest sixth of a second. The arrangement of the apparatus put the S. on the end and E. on the long side of a table, so that each could hear the other readily. The dial on the chronoscope was not visible to the S.

The stimulus words in this experiment were the first 320 of the list used by Thorndike and Rock.[1]

[1] This list was available through the kindness of Dr. Irwin, who had obtained it from Dr. Rock.

The operation of the voice keys was demonstrated in a brief practice period during which E. gave *one, start,* or the S.'s first name as stimuli, and S. was instructed to reply with *two, stop,* or his last name. An equal amount of practice was given to responses by sequence and by opposite.

Announcement of *Right* or *Wrong* was made before recording the response or the time. Responses which seemed clearly due to habitual language sequences were announced as *Right,* others as *Wrong.* For example, *darling–daughter, September–October,* and *immoral–practices,* were all announced as *Right.* There were, of course, borderline responses, and in a few cases no announcement was made to the S. But since all the other experiments permitted immediate and sure judgments of correctness, any considerable number of such deferred judgments might have given extraneous leads to the Ss. At the expense of occasional error, therefore, to be corrected in the later rescoring, some announcement was made wherever possible; fewer than twenty of the entire series of responses received no announcement.

Differences between this procedure and that used by Thorndike and Rock which are important in their effect on the Ss. are found in the presence of the chronoscope, and the announcement of the number right in each 20 responses, and in the fact that the instructions and the repeated introspections made it explicit that a problem was to be solved, and that some system underlay the assignments of Rights and Wrongs.

II. *The Speed Experiment* was identical with the Sequence Experiment in instructions, procedure, and stimulus list. The only difference between them lay in the principle used in assigning Rights and Wrongs. In this case the response was announced as *Right* if the reaction time was 8/6 of a second or less. (Since the readings were merely to the nearest sixth, the more accurate statement would be that the correct response took less than 1.4 seconds.)

III. *The Rhythm Experiment* was given with the following instructions:

> "I shall say a word, and you are to reply as rapidly as possible with the first word or words that comes to mind. I shall say *Right* or *Wrong,* depending on whether your response is one of the words which I have decided shall be right for the stimulus word in question. We shall then proceed to the next word in the same way. After each twenty words I shall tell you how many responses in that group were right; you will make your introspections at that time."

The stimulus words in this case were a list of 320 words, half of

them from the second and half of them from the fourth 500 of the Thorndike list of 10,000 words (18). The responses were not timed.

Right was announced if the response word matched the stimulus rhythmically, *i.e.*, had the same number of syllables, and the accent similarly placed. Stimulus words of uncertain accent were marked in E.'s list, and read always with the same accent; examples are *conduct′*, *eight-een′*, and *her-self′*. The response word had to be similarly marked in the record. For instance, in the examples cited *nineteen* and *himself* were frequent responses; in common usage they are accented variously according to context. In the responses obtained here they were uniformly on the first, or differentiating syllable, and were thus uniformly wrong.

IV. *The Parts of Speech Experiment* had the following instructions:

"I shall say a word, and you are to reply with some number from 1 to 6, inclusive. I shall say *Right* or *Wrong* depending on whether you have hit on the right number to go with the stimulus word in question. We shall then pass on to the next word in the series. The object is to see how quickly you can learn to make your responses entirely or substantially correct. After each twenty words I shall tell you how many responses in that group were right; you will make your introspections at that time."

The stimulus words were a list of 100 drawn largely from the fifth 500 of the Thorndike list of 10,000 (18).

The number code in this experiment was Nouns–1, Verbs–2, Adjectives–3, Adverbs–4, Prepositions–5, Pronouns and Conjunctions–6. Scoring was definite and easy, since ambiguous words had been excluded from the list.

The procedure in this case involved the presentation of not more than 300 words, which meant going through the stimulus list as often as three times in some cases.

V. *The Vowel Experiment* had the following instructions:

"I shall say a word, and you are to reply with some number from 1 to 5, inclusive. I shall say *Right* or *Wrong,* depending on whether you have hit on the right number to go with the stimulus word in question. We shall then pass on to the next word in the series. The object is to see how quickly you can learn to make your responses entirely or substantially correct. After each twenty words I shall tell you how many responses in that group were right; you will make your introspections at that time."

The stimulus words here were a list of 320, half from the first, and half from the third 500 of the Thorndike list of 10,000 words (18). Right was assigned in this experiment if the response number stated the number of vowels in the stimulus word.

VI. *The Frequency Experiment* was similar in form to the other two number code experiments. Instructions were:

"I shall say a word, and you are to reply with some number from 1 to 4, inclusive. I shall say *Right* or *Wrong,* depending on whether you have hit on the right number to go with the stimulus word in question. We shall then pass on to the next word in the series. The object is to see how quickly you can learn to make your responses entirely or substantially correct. After each twenty words I shall tell you how many responses in that group were right; you will make your introspections at that time."

The stimuli in this experiment were 320 words drawn from Thorndike's list of 20,000 words (19).

Words appearing in the first, second, third, and fourth quarters of that list were assigned respectively the numbers 1, 2, 3, 4. Detailed analysis of this list, like the others, will be presented below. The first three words in each category are cited as samples.

Most Frequent			*Least Frequent*
1	*2*	*3*	*4*
nowithstanding	amnonia	benzene	attainder
queen	demonstrate	broadcloth	chancel
represent	subway	congest	cresset

To classify even 12 such words so as to agree with an objective determination of their frequency of use is no easy task; to derive the principle of classification inductively proved too difficult for any of the Ss. used, although one of them approached a solution. This very difficulty of the problem, coupled with the fact that although there is never more than one right response to a given stimulus the wrong response may vary in amount of error, permits fine discriminations in the scoring, and thus a good measure of learning. Announcement to the Ss. was on the basis of an all or none decision: he was right, or he was wrong, and after each twenty words he was told merely the number right. But any S. who was responding purely at random would be as likely to get one wrong answer as another, whereas approach to learning of the system should show itself not only in the higher proportion of right answers, but in a smaller proportion of answers which are more than one place removed from the correct one.

Deviation Scores, or *dv. Scores,* were therefore computed for each group of 20 words, representing the total deviation of the wrong answers divided by 20. With equal numbers of words in each classification, and scoring on a right or wrong basis, a purely random performance would show one quarter of the responses correct. On the basis of the dv. score a random performance would have an expected

score of 1.25, arrived at as follows. For each stimulus word there are four equally likely response-numbers, one right and three wrong, giving us 16 cases to consider. Expected deviations for the "1" stimulus words are 0, 1, 2, 3, or a total of 6. The similar expectations for the "2" words are 1, 0, 1, 2, or a total of 4. The same expectations hold respectively, for the "4" and "3" words, giving a total expected deviation of 20. Dividing by 16, the number of cases, we get the expected chance score of 1.25. In practice the expected scores for Ss. who favor 2 or 3 in their responses would be better than 1.25, and worse for those who favor 1 or 4.

It is apparent that this scoring system has many possibilities in exploring not only the relationship of awareness to learning, but also the effects of reward and knowledge of results on learning. A marked improvement in dv. score is possible within a series of records none of which would appear to the learner to show better than a chance performance on the basis of the mere announcement of right or wrong.

CHAPTER IV

THE STIMULUS LISTS

Since the time of Ebbinghaus nonsense syllables have been used extensively in the study of learning and memory; with some experimenters, and at certain periods, this usage has been so extensive as practically to exclude meaningful words from all experiments involving word association. This trend alone, lasting as it has over a period of half a century, is strong enough evidence of the difficulties facing anyone who undertakes to set up meaningful stimulus material for such experiments, and of the devious problems and pitfalls which beset anyone who attempts to interpret association word data based on such stimuli.

The present experimenter is all too strongly conscious of these difficulties and these pitfalls. But there are other—albeit perhaps somewhat more subtle—problems involved in the interpretation of data drawn from nonsense material. In these experiments, accordingly, the effort has been made to control, or at least to determine, the stimulus values of the meaningful words used, rather than to try to equate the stimuli by making them all meaningless. This effort has not been such as to provide a complete study of the stimulus values of the words, nor final evidence of such values within the fields which have been explored.

There is a strong possibility, however, that the ultimate value of the present paper will depend more on the experimental methods used than on the experimental results; specifically, that it will depend on the methods used or suggested for controlling the stimulus values of meaningful words. Whether or not this judgment proves correct, it represents the author's bias, and no further apology need be offered for the length of the present section.

Before presenting the detailed analyses to which the stimulus lists have been subjected, it will be well to consider broadly the types of analysis which should properly be applied to meaningful words used as stimuli in association word experiments.

Words should be differentiated first so as to make four vocabularies for each subject: the heard, the spoken, the seen, and the written, and to show the relationships of one to another.

Second, special attention must be given to homonyms in the heard and spoken, and to homographs in the seen and written vocabularies.

Third, within all four of the above vocabularies, attention must

be given to the variety of meanings which a given word may have. The importance of this aspect of words is illustrated by contrasting the associative richness of such words as *draw* and *draft* with that of *sing* and *song*. The two pairs are alike in derivation, and in the relationship which the second member has to the first. All four words rank in the commonest 2500 in the language on the evidence of the Thorndike word list, and the two verbs in the commonest 500 (19). Such differences as exist between them are due in part to the range of their use rather than to frequency. This factor of range of use has apparently never been adequately studied.

Two other factors affecting the stimulus values of words are their frequency of use, and the length of time they have been in the subjects' vocabularies. There is a relationship, but by no means a correspondence, between these two. Thus for adults the four words *baby, cradle, dolly,* and *bunny,* all of which are among the common words of the Kindergarten Union word list (6), may be assumed to be approximately equal in length of acquaintance. But they are ranked respectively in the 1st, 3rd, 5th, and 13th 1000's of the Thorndike word list (19), based on a wide sampling of written usage.

A sixth factor, or group of factors, is concerned with the emotional values of words. This has, in view of the wide use of the association word method in the study of the emotions, received more attention than many of the others, but a broader and more carefully controlled approach is needed.

Somewhat allied to the emotional value of a word is the imaginal value it may have. We are concerned here both with the familiar distinction between abstract and concrete, and with the possibility that words may vary in evoking images from different modalities and of different degrees of vividness.

Another way in which words differ, English words especially, is in etymology. This may be of almost no importance in the present connection if other factors can be held constant. But there have been frequent and largely unsupported references by literary critics to the vigor and emotional values of words of this or that derivation; the facts back of such references deserve study.

Even more obvious are differences according to grammatical form or use. This has already been considered in the citation from Crane's work (3).

A final type of difference, more superficial and easier to study, is to be found in the aspects of words which are incidental to their basic symbolic values. Spelling, length, visual pattern, tone color,

rhythm, pitch,—one convenient grouping can be made of all the aspects of a word which could be profitably observed by a student with no knowledge of the language from which it is drawn.

The summary above lists ten factors affecting the stimulus values of words. They are stated only very broadly, so that possibly none of them is prime. Furthermore, the effects of such aspects of the stimulus words on association word responses are essentially unknown. Yet such effects must be comprehensively studied if the association word method is to provide valid generalizations about such functions as perception, learning, insight, closure, and the like, or about the psychology of language. The job will probably be done piecemeal and slowly; but it is worth doing, and the psychologist now has available in frequency lists, experimental and statistical techniques, and experimental results, the means of approaching the problem. Its solution will depend in part on evidence from other fields,—education, philology, grammar, semantics, and what not. Conversely, the psychologist can probably contribute as much to workers in these fields as he borrows from them.

Some of the factors mentioned above have been used in the analysis of the stimulus lists for these experiments. Others have been left uncontrolled and unmeasured.

List I, used in the Sequence and Speed Experiments, consisted of the first 320 words of the list used by Thorndike and Rock (21). It will be recalled that the results from two groups of their Ss., who differed only in the order of presentation of stimuli, were so different as to suggest that differences within the stimulus list itself might account in part for what they found.

This list was accordingly checked first against the Kindergarten Union list of the commonest 2500 words in the spoken vocabularies

TABLE I

NUMBER OF KINDERGARTEN UNION WORDS IN LIST I, SEQUENCE AND SPEED EXPERIMENTS

1st 80	*2nd 80*	*3rd 80*	*4th 80*
3	4	4	2
5	3	3	3
8	9	6	7
8	10	7	5
7	2	5	7
6	7	7	5
5	9	4	6
5	5	4	4
47	49	40	39

of children entering school (6). The facts are presented in Table I, arranged to show the figures both by successive 10's and successive quarters of the list.

The range is considerable for words of this type, which we may judge with some confidence to have been longest in the speaking vocabularies of the Ss. This factor of length of acquaintance should be expected *a priori* to have some effect on the Sequence and Speed Experiments.

The amount of this effect, however, will depend in part on the relative familiarity and length of acquaintance of the other words in the list. The six 10-word groups containing only 2 or 3 words each from the Kindergarten Union list were accordingly checked against two other frequency lists. The Free Association (1) list, representing vocabularies of school children, was found to contain 33 of the 44 stimulus words under consideration—those not in the kindergarten vocabulary. Of these 33, 27 were reported from Grades II to VI, the other 7 from Grades VII and VIII. The same 44 words were located as follows in the Thorndike word list (19): 26 in the first 5000, 11 in the second, 4 in the third, and 3 in the fourth. The 11 words in this group which were not in the Free Association list were placed in the following 1000's of the Thorndike list: *benign* 10, *dative* 18, *genitive* 20, *gnash* 10, *Boston* 3, *cerebral* 16, *geological* 15, *betwixt* 7, *centralize* 15, *defer* 8, and *focus* 7.

This introduces the consideration of the frequency of the words in this list in current usage. As might be inferred from the evidence already presented, the list proved to be fairly homogeneous in this respect; over 300 of the 320 words were among the commonest 10,000 of the Thorndike word list. A more detailed check against the Thorndike list is not likely to be profitable: a study by Dale (4) indicates that about three quarters of the first 1000 words in the Thorndike list are found also in the Kindergarten Union list.

There is good reason to believe that although the proportion of words from the Kindergarten Union list varies materially within List I, these 320 words do not differ widely with respect to familiarity or length of usage. No frequency list with which it might be compared is free of error; and this stimulus list, considered in relation to either of these usage criteria, might well lie within or close to the limits of sampling error of any published study of adult vocabularies. Thus two of the many possible variables are found to be within reasonably narrow limits.

List I was subjected to one other type of analysis; that according to grammatical classification of words, as follows:

Nouns,—words which can be used *only* as nouns, except for the attributive use possible for almost all nouns, *e.g., century* (*plant*), *Alice* (*blue*).

Verbs,—words which can be used only as verbs, *e.g., defer, centralize.*

Modifiers,—words which can be used only as adjectives, *e.g., benign;* only as adverbs; or as either. Exception was made of elliptical and idiomatic extension, usually to noun usage, *e.g., the dative, for always.*

Others,—words which can be used as none of the above four parts of speech.

Ambiguous,—words which can be used in more than one of the above ways.

Obsolete and rare usages were not considered. In doubtful cases the *Shorter Oxford Dictionary* was consulted; but in most cases the decisions were easily made. The distribution on this basis was such that there was no reason to expect a finer classification to give significant results. The findings are presented in Table II.

TABLE II

DISTRIBUTION OF WORDS IN LIST I ACCORDING TO GRAMMATICAL CLASSIFICATION, SEQUENCE AND SPEED EXPERIMENTS

List by 20's	*Nouns*	*Verbs*	*Modifiers*	*Ambiguous*	*Others*
1	5	2	6	7	0
2	4	1	4	11	0
3	2	1	4	13	0
4	2	3	4	11	0
5	3	2	4	10	1
6	3	1	4	12	0
7	1	8	3	7	1
8	2	2	3	13	0
9	1	3	5	10	1
10	8	1	1	10	0
11	1	1	4	14	0
12	5	0	1	13	1
13	3	5	5	6	1
14	6	2	4	7	1
15	2	4	5	9	0
16	5	2	5	8	0
Totals	53	38	62	161	6

The arrangement of List I was such that the 1st, 41st, and each 40th word thereafter began with *a;* the intervening words were approximately in alphabetical order.

List II, used in the Rhythm Experiment, was made up of 320 words, selected so as to hold the factors of frequency more nearly constant than in List I. Random samples of 160 words each were made from the second and fourth 500's of the Thorndike list (18),

arranged in alphabetical order, and then were copied off in the final form by taking every fifth word, going through the list five times.[1] Words from the two lists were then alternated in groups, so that List II, as presented to the Ss., had the first and successive odd-numbered 20's drawn from the second, and the even-numbered 20's from the fourth 500 of the Thorndike word list.

For comparative purposes List II was checked against the Kindergarten Union word list. The number of such words per 20 words in List II ranged from 5 to 14. In seven cases the odd-numbered group had more of these words than the even-numbered list which followed; in the eighth case the number was identical.

It will be remembered that the principle determining the announcement of Right in the Rhythm Experiment was that the response should match the stimulus in number of syllables and accent. These two factors were left entirely uncontrolled, on the grounds that a list selected with the rhythmical characteristics of the stimuli in mind would certainly have involved the risk of a simultaneous and undesirable selection according to length, frequency, familiarity, etymology, or other aspects of the words which would serve to complicate or obscure the learning in undetermined ways. After the list was prepared, however, selected on the basis of frequency, a distribution was made according to number of syllables; this appears in Table III.

TABLE III

DISTRIBUTION OF WORDS IN LIST II ACCORDING TO NUMBER OF SYLLABLES, RHYTHM EXPERIMENT

List by 20's	*1*	*2*	*3*	*4*	*5*
1	9	9	2	0	0
2	8	9	2	1	0
3	15	5	0	0	0
4	7	10	2	1	0
5	8	9	3	0	0
6	12	6	2	0	0
7	16	4	0	0	0
8	13	6	1	0	0
9	15	4	1	0	0
10	7	10	3	0	0
11	12	5	3	0	0
12	5	8	5	2	0
13	15	5	0	0	0
14	10	8	2	0	0
15	13	5	2	0	0
16	10	8	1	0	1
Totals	175	111	29	4	1

[1] Clerical errors incidental to this procedure resulted in 4 duplications, so that the list had 316 different words.

List III, used in the Parts of Speech Experiment, consisted of 100 words, drawn largely from the fifth 500 of the Thorndike word list (18), although it was necessary to go back into the first 2000 words of this list to get enough words appropriate to the purpose. The list was thus roughly equal as to frequency and length of acquaintance.

This experiment involved response to the stimuli with coded numbers, assigning 1 to nouns, 2 to verbs, 3 to adjectives, 4 to adverbs, 5 to prepositions, and 6 to other parts of speech. It was essential, therefore, to eliminate all such words as *aloud* (*allowed*), which would be ambiguous with an auditory presentation, as well as the more obviously ambiguous words as *voyage, rage, poison,* and those which were more subtly so, as *domestic, stoop,* and *stole.*

Five balanced lists of 20 words each were arranged on these principles; each put into alphabetical order. The number of words of each type was as follows: No. 1—9 words, No. 2—4 words, No. 3—3 words, No. 4—2 words, No. 5—1 word, No. 6—1 word. Since the order was alphabetical, it happened that several times there were three 1's in succession, and on two of the pages the first three words were in the order 1–2–3. The five words with No. 6 as correct answer were three pronouns and two conjunctions. The number of words of each type represented in each 20 was in rough proportion to the number of available words of each type. This proportion, furthermore, was such as to facilitate rapid learning. Any S. who hit on the hypothesis that the key lay in a grammatical classification would be able to get an almost perfect performance at once,—if only he was well grounded in grammar.[2]

List IV, which was used for the Vowels Experiment, consisted of 320 words, half from the first, and half from the third 500 of the Thorndike word list (18). The preparation of this list was similar to that of List II, and in the final list the two levels of frequency alternated in the successive groups of 20 words presented to the Ss. This list was similar to List II also in the fact that the criterion governing the announcement to the Ss.—in this case the number of vowels in the stimulus word—was purposely disregarded in selecting the words. The distribution of correct answers is shown in Table IV, by successive 20's.

As in List III, used for the Parts of Speech Experiment, the distribution of correct answers probably favors the Ss. who favor the lower numbers in their random responses. But the amount, and even

[2] The distribution similarly favored any Ss. who, while responding largely at random, tended to 1, or 1 and 2, for most of their responses.

TABLE IV

DISTRIBUTION OF WORDS IN LIST IV ACCORDING TO NUMBER OF VOWELS, VOWELS EXPERIMENT

List by 20's	*1*	*2*	*3*	*4*	*5*
1	11	6	2	1	0
2	3	9	7	1	0
3	10	8	2	0	0
4	7	5	8	0	0
5	12	8	0	0	0
6	3	10	7	0	0
7	11	8	1	0	0
8	5	10	4	1	0
9	8	9	3	0	0
10	6	12	2	0	0
11	4	11	3	2	0
12	7	11	2	0	0
13	5	10	5	0	0
14	6	12	1	0	1
15	5	9	5	1	0
16	7	10	3	0	0
Totals	110	148	55	6	1

the direction, of the advantage to be expected from this skewed distribution is uncertain.

List V, used in the Frequency Experiment, proved to be the most difficult of the stimulus lists for the experimenter to prepare, just as the problem it presented was the most difficult of the series for the subjects. It will be recalled that responses were to be by numbers from 1 to 4, representing the placement of the stimulus words in the first to the fourth quarters respectively of the Thorndike list of the 20,000 most frequently used English words (19).

This problem had been substituted for a similar one, based on a different word list, and requiring classification into eight groups rather than four. The earlier one called for such fine discriminations that Ss. thoroughly informed as to the principle involved were unable to give better than a chance performance in applying it. The problem in devising List V was thus twofold. The intervals between steps had to be great enough so that Ss. instructed as to the frequency principle should be able at least to approach a correct application of it. Second, the words had to be chosen so that Ss. could not be expected to get high scores by responding to the length of the stimulus words, or to any aspect of them other than the correct one.

The first step was therefore a sampling of about 500 words, which were then divided into four groups according to their placement in the four quarters of the Thorndike list. In making this sampling

homonyms were largely, but not entirely eliminated. *Serf,* for example, was acceptable, since a response of *2* would be right for *surf* as well. Neither *birth* nor *berth,* which would be scored 1 and 2 respectively, could be considered, however.[3]

Distributions of each group of words were then made according to the number of syllables, and all words of more than five syllables were arbitrarily discarded. Selection was made among the others so as to have an approximately equal number of words of each length within each numerical grouping. The final selection was on the basis shown in Table V. The right hand column shows the number of

TABLE V

DISTRIBUTION OF WORDS IN LIST V ACCORDING TO NUMBER OF SYLLABLES, FREQUENCY EXPERIMENT

Right Answers	*1*	*2*	*3*	*4*	*5*	*Totals*
1	9	37	22	5	3	76
2	10	36	25	9	3	83
3	9	37	26	9	3	84
4	6	33	27	8	3	77
Totals	34	143	100	31	12	320

words in each of the four categories; the bottom line the number of words of each length.

In cases where more words of a given length were available than were needed, the choice was made so as to differentiate as sharply as possible between the groupings. Thus, for placement in the *1* and *4* groups, preference was given to words in the 1st and 20th 1000's over those in the 5th and 16th. Similarly, preference in the *2* and *3* groups was given to words from the 8th and 13th 1000's. Among words of equal frequency according to the published list, choice was made of those which seemed to the experimenter to be most representative of the frequency level.

No effort was made to follow other criteria in selection, such as part of speech, derivation, or whether the word was a compound one. This should probably have been done. Many compound words of familiar meaning are nevertheless sufficiently rare in written usage to earn a rank of *4;* examples of such words are *flagship* and *groundwork.* A similar difficulty was found with such words as *conveniency, stoppage, waywardness,* and *sensitiveness,* all of which are classified

[3] Prepared originally from the *Combined Word List* (1), which gives the Thorndike ratings, List V contained three words not in the Thorndike list: *wastepaper, timetable,* and *foxtrot,* rated 1, 1, and 2.

as *4*, although the familiarity of both stems and affixes leads even informed Ss. to rank them lower. Both these groups of words are quite different qualitatively from such other *4* words as *llano, pismire, anathematize, ulcerate,* and *maharajah.*

The 320 words as chosen above were then put into alphabetical order, and the stimulus list as presented to the Ss. drawn up by taking each 10th word, and going through the list until it was exhausted. This procedure resulted in considerable variation in the number of correct answers of each type in successive 20's of the stimulus list; these facts are shown in Table VI. List V was checked also against

TABLE VI

DISTRIBUTION OF CORRECT ANSWERS IN LIST V, FREQUENCY EXPERIMENT

Successive 20's of List	*1*	*2*	*3*	*4*
1	1	2	8	9
2	3	6	7	4
3	3	9	5	3
4	7	3	5	5
5	7	4	2	7
6	6	4	4	6
7	2	4	9	5
8	5	3	10	2
9	4	7	5	4
10	5	7	5	3
11	5	5	5	5
12	7	4	5	4
13	7	5	4	4
14	5	5	5	5
15	6	6	2	6
16	3	9	3	5
Totals	76	83	84	77

the Kindergarten Union word list: two of the 20 word groups had none of these words; nine had either one or two, and five had from three to five.

The above distribution, although irregular, is not such as to favor consistently Ss. with apparent preferences in their choice of response numbers.

It remains to be seen what performance can be expected on this problem when the Ss. need not derive the principle, but merely apply it. A control experiment was therefore run, using 8 Ss. fully informed as to the principle involved. The best score in this experiment, obtained twice by the same S., was 16 right out of 20 words. The average number right, per list of 20 words, ranged from 12.1

to 6.4. Only 7 individual scores out of the 128 fell as low as the chance expectation of only 5 right. Deviation scores ranged from .45 to .92 for the 16 groups of 20 words each, with a median of .63. Only two of the 128 individual scores were as poor as the expected chance score of 1.25, and including these two scores, there were only six as poor as 1.00. These scores provide a standard against which to measure the performance of the Ss. reported below who did the Frequency Experiment as a problem to be solved.[4]

[4] This control experiment was devised only as a check on List V, and as such it has served its purpose. A more extensive experiment along the same lines is planned, which should help to provide useful data bearing on the validity of frequency lists as they are used in education.

CHAPTER V

RESULTS

Table VII presents a summary of the results, showing for each S. which of the experiments were performed and the order in which they came; those which are starred are the ones for which the S. stated a correct solution. The table represents fairly well the relative difficulty of the problems, except for the Speed and Rhythm Experiments,

TABLE VII

Ss.	*Experiment*					
	Sequence	*Speed*	*Rhythm*	*Parts of Speech*	*Vowels*	*Frequency*
A				1*		
B	1*		3*	2*	4*	5
C		5	2*	4	1*	3
D		1, 3	6	4	2*	5
E	4*		1	3*	5*	2
F		2*	4	1*	3*	5
G			2			1
H	2*				1	

* Indicates solution.

in which there were some partial solutions. D responded to a total of 640 words in the Speed Experiment, 320 in each sitting.

The Sequence Experiment

Table VIII presents the scores, by number of correct responses per 20 words, when the six Ss. who responded to List I were scored on the Sequence principle. Three of these Ss., B, E, and H, had the announcement to them of Right and Wrong made on this principle. Announcement to Ss. D, C, and F, was based on their speed of response, with the figures in Table VIII obtained by a later rescoring.

The records of Ss. B, E, and H, to whom announcement was made on the *sequence criterion,* bear out what was thoroughly established elsewhere, that a perfect performance on this problem comes slowly, even after the S. is aware of the underlying principle. Some of the reasons for this can be seen in the introspections.[1]

[1] Citations from the protocols will be identified in the following form: *B, 1st, 1,* or *F, 5th, 7.* This should be read to indicate that B did the experiment as her first, and that the statement was made after her first 20 responses, or that F, in what was his fifth experiment, made the statement after his 7th group of 20 responses. When specific items are referred to, both stimulus and response

TABLE VIII[a]

NUMBER RIGHT, BY SEQUENCE PRINCIPLE, LIST I

20 Word Units	When Announcement to Ss. Was Based on: Sequence — Ss. B	E	H	Speed — Ss. C	D	D[b]	F
1	*9**	*7*	*7*	11	5	7	8
2	14	14	10	6	*6*	5	5
3	19	19	*12**	15	8	7	8
4	18	20	18	13	8	6	*10**
5	17	*18*	15	8	1	2	2
6	17	*17**	17	16	8	6	
7	20	19		13	2	1	
8	20	18		14	7	9	
9				*15*	6	5	
10				9	*8*	7	
11					3	5	
12					5	6	
13					10	7	
14					5	5	
15					*7*	7	
16					*7*	5	

[a] Italics indicate that after receiving the score in question, the S. made an introspection significant in his solution. The * marks his statement of the correct principle underlying the announcement to him of *right*.

[b] The two sets of figures for D refer to his first and second sets of responses to the stimulus list. These came a week apart, and were separated by his solution of the vowels problem.

B, 1st, 1. 9 right.

"The stimulus words usually called up reaction words of opposite meaning. Some words, such as 'daughter' I thought of in the title, 'Yes, My Darling Daughter' (*darling–daughter,* 8). For others, 'carriage' (*carriage–wheel,* 12) for example, I visualized a moving carriage and the wheels. . . From my second success (*casual–chance,* 13) on I seemed to feel that the reaction should be one that was frequently used in connection with the stimulus word—as '*bamboo–stick*' (10); but this affected my actual response very little. I usually thought of a word that would probably be right soon after my response."

B, 1st, 2. 14 right.

"I felt that I knew what was wanted; and yet I couldn't think in terms of the desired response after the first 6 or 7 words. (9 of the first 10 words were in fact correct.) I felt that there was much more effort and less spontaneity to my response when I tried to give the word I thought was right.

"Immediately after replying I knew whether or not I had given the right answer—that is, before I was told. In the case of 'long' (*lawn–box,* 8, or *long–short,* 16?), I thought of its opposite, but knew that I should have given a

will be shown in parentheses. Reaction times, in sixths of a second, are stated for the Sequence and Speed experiments. The number of correct answers in the group of 20 is stated in each case.

word like 'box.' There was a decided conflict on the word 'doctor' (*doctor–country,* 18) because I tried to give one word I thought was right, but another seemed to have equal weight. As a result, I was confused, and reacted very slowly.''

B, 1st, 3. 19 right.

''I can't remember what my first response was, but I knew it was wrong before I said it (*able–willing,* 18). . . . I found it less hard to give the desired response this time. While I am giving words my thoughts are in terms of merely giving the right answer. The reward plays no part at all during the experiment.''

E, 4th, 1. 7 right.

''My response to the first stimulus 'adverb' was verb (*adverb–verb,* 7). This was the first word that came to me after the stimulus word. However, this stimulus threw me off the track for I immediately began to think that what was wanted was answers similar to the ones given in the number experiment (Parts of Speech) although no mention of this was made. With this thought in mind I began to classify the next stimuli into parts of speech and then place them under certain numbers. Having the time element enter into it, it was difficult to (do this) quickly. However, after several tries I was able to do this more quickly and correctly, but my answers were wrong. Therefore . . . I went back to what the directions said, that is, to say the first word that came to me after the stimulus. This I found was the correct method.

After the first response, cited above, E responded with numbers to the next 11 stimuli. Of her last 8 responses, all were clearly of the sequential type except *film–lab, 4,* which was counted wrong, but is questionable.

E, 4th, 2. 14 right.

''This time I responded as directed. I found that the quicker I responded the more likely my answer was to be right. With the word 'smooth' (*smooth–rough,* 11) I found myself trying to repeat it, rather than responding with another word. That is why I hesitated.''

E, 4th, 4. 20 right.

''I have found that I am more likely to give a correct response to the stimulus if at the time the stimulus is given I have my mind as void of other thoughts as possible, thereby giving the stimulus more of a chance to bring the correct response, for my mind is relatively free of any blockage.''

E, 4th, 5. 18 right.

''I find that when the word stimulates me to think of a situation rather than just a word response I am very likely to give some word describing the situation rather than the correct response word. For example, the stimulus word 'fight' (*fight–cats,* 7). Most naturally I should have said 'me' as a response word, but instead the situation of a cat fight entered into consciousness and I answered in a word descriptive of it, 'cat'.''

E, 4th, 6. 17 right.

''Every response that I had wrong this time I knew was wrong before being

told. Correct responses are those that add to—or complete the stimulus word, rather than being opposites or similar to it. . . ."

E, 4th, 7. 19 right.

"Although I have said before that the less conscious direction the more likely the response is to be correct, this is not quite true. For now that I realize what I said above is true, I find myself consciously directing my responses to words that will add to or complete the stimulus word. I might also add, that process consists of blocking out all other possible responses rather than making an actual choice when the stimulus is given, for this would take too long."

The quantitative records are consistent with those reported by Thorndike and Rock (21), and by Irwin and others (8), using the same word list and essentially the same procedure; with constant reward of *rights,* Ss. give an increasing proportion of sequential responses. Taken in connection with the introspections they confirm the second of the above studies: awareness of the basic principle does not bring immediate or consistent success. Both of these findings had been adequately established in those earlier studies.

The introspections by E are of especial interest. After having reported in three experiments, E was unable to state the principle of the Sequence Experiment until after 120 stimulus words. Yet it is apparent that there was little or no learning beyond that involved in giving up a principle learned in a previous experiment. Once she had done so, 7 of the remaining 8 responses in the group of 20 were correct, and all but 9 of the next 80. This record was obtained by leaving the mind as open as possible, and allowing the stimulus word to control the response. This record confirms the statement quoted above from Thorndike and Rock (21, 9–11): "If the tendencies that produce a word or words when a word is heard had been allowed to operate undisturbed, the speech-writing tendency would, in our opinion, have been strengthened in all persons in whom it operated at all."

The Speed Experiment

Tables IX and X give respectively the number right and the average times of response per group of 20 words when the Ss. responding to List I were scored on the basis of speed of response. These tables, are, of course, just the reverse of Table VIII, *i.e.,* in this case Ss. C, D, and F had the announcement of *right* based on the principle used in the scoring, whereas D, E, and H had the announcement based on the sequence principle, and were rescored later on the time basis.

Several features in Tables IX and X deserve comment. C, for

TABLE IX[a]

NUMBER RIGHT, BY SPEED PRINCIPLE, LIST I

20 Word Units	*When Announcement to Ss. Was Based on*						
	Speed				*Sequence*		
	Ss.				*Ss.*		
	C	*D*	*D*[b]	*F*	*B*	*E*	*H*
1	20	10	14	12	*8**	*17*	*9*
2	16	*19*	20	16	6	15	11
3	20	15	15	12	9	17	7*
4	18	13	16	*11**	10	18	15
5	16	14	18	18	6	*17*	12
6	17	14	16		10	*17**	11
7	14	12	18		10	17	
8	17	10	14		8	17	
9	*15*	15	20				
10	14	*17*	17				
11		15	17				
12		11	16				
13		14	17				
14		14	18				
15		*10*	18				
16		*13*	14				

[a] *Cf.* Note a, Table VIII.
[b] *Cf.* Note b, Table VIII.

TABLE X[a]

AVERAGE REACTION TIMES, IN SIXTHS OF A SECOND, LIST I

20 Word Units	*When Announcement to Ss. Was Based on*						
	Speed				*Sequence*		
	Ss.				*Ss.*		
	C	*D*	*D*[b]	*F*	*B*	*E*	*H*
1	6.2	8.5	8.7	10.0	*11.1**	*7.7*	*9.9*
2	6.4	*6.7*	5.9	7.5	11.0	6.5	8.7
3	5.6	7.5	7.6	8.8	10.1	6.8	9.8*
4	6.3	8.3	7.1	*9.5**	14.9	6.7	7.6
5	7.7	8.0	7.0	5.9	13.3	*7.3*	9.5
6	6.4	8.2	6.5		10.2	*6.9**	8.8
7	7.5	8.6	6.6		9.6	6.9	
8	7.0	8.8	7.4		9.5	6.4	
9	*7.2*	7.8	6.3				
10	7.4	*7.0*	5.8				
11		7.4	6.4				
12		8.5	7.2				
13		7.5	7.0				
14		7.8	6.2				
15		*10.6*	6.9				
16		8.6	7.8				

[a] *Cf.* Note a, Table VIII.
[b] *Cf.* Note b, Table VIII.

example, was initially the most rapid of the Ss. in response: his first 20 responses, and 56 of his first 60 met the criterion of 8/6 of a second or less. In short, he had little or nothing to learn, so far as the performance went, and his performance got pretty steadily worse as he continued to respond. Equally interesting are the sharp increase in number right, and sharp drop in time score as soon as F stated the correct principle; but even with the correct principle he did not get a perfect score. Somewhat less obvious are the improved scores among the later responses by B and E, who had the announcement of *rights* on the sequence basis. This is more noticeable in the case of B, who stated the correct principle tentatively after the first 20 words, but did not receive a perfect score until the seventh group of 20.

Further comment will be reserved until after the citation of some introspections.

C, 5th, 1. 20 right.

"I don't know if there is any special system . . .; all I have done so far is to respond with the first words which came into my mind, all of which have been synonyms, opposites, or usually used with the stimulus, and still I hit all correct."

C, 5th, 5. 16 right.

"Oftentimes the stimulus gives a different meaning or spelling to the subject, so that the response, though logical, is not correct.

"So far it seems that if the response is in any way related to the stimulus it is correct."

C, 5th, 7. 14 right.

"It still seems that any related response is correct.

"I find that practice does not help any, as is evidenced by my low score of 14 on this trial; it may have the opposite effect in causing the subject to tire."

C, 5th, 8. 17 right.

"I am still following the theory of responses relating to the stimuli, but I was set back when 'color' was wrong for stimulus 'paint' (*paint–colors,* 11).

"(E) says I don't have the correct system, and it is disturbing to obtain high scores without knowing what you are doing."

C, 5th, 9. 15 right.

"I thought that slow time may have been the cause of wrong answers, but I find that quick responses, if illogical, are wrong."

C, 5th, 10. 14 right.

"I can't understand why 'lead me' (*league-me,* 6) is right, but 'leave me' (*leave–me,* 9) wrong, and why 'flies' for butter–fly (*butterfly–flies,* 9) should be wrong."

Tersely described, C's record seems to show not learning without awareness, but unlearning with awareness. A perfect initial

score became steadily worse; and although C stated the speed hypothesis after 180 responses, his subjective judgment of time was faulty, and he rejected it. His introspections show what was apparent several times in this series of experiments: that under certain conditions the "reward" of an announced *right* can be a real annoyer. The last of C's introspections is an illustration of how natural the sequence principle seems to Ss. responding by free association. After the last introspection reported above, which followed the 200th response, C was unwilling to proceed. In the experimenter's opinion, furthermore, his motivation was so changed that continuance of the experiment would have involved an entirely different type of problem. The experiment was therefore dropped, with the solution stated by C, but unrecognized.

D's record showed quantitative improvement, but the same inability to recognize a solution of the problem.

D, 1st, 1. 10 right.

"One word gave no association whatsoever, but finally an unrelated word came to my mind. Recent experiences seemed to affect my response. The first few were by definition, but later changed to opposite or like words."

D, 1st, 2. 19 right.

"For the most part, my responses seem to be coming faster although some words tend more toward giving responses than others. Fewer definitions here, more opposites, and a few complementary words such as (*needle–thread,* 7) etc."

D was thus aware very early of his speed of response, as well of the presence of synonyms, antonyms, and sequents in his responses. But he connected none of these things with the announcement of *right,* and he did not again obtain so good a score, either in average time or number right, until the second presentation of the same 20 words, *i.e.,* until after 300 intervening words, and the lapse of a week. D was not, in the ordinary sense, a sophisticated subject; but in an elementary course in psychology he had recently been introduced to the Kent-Rosanoff material. This partial acquaintance affected his responses in an undetermined way: it clearly had a material effect on his introspections, and probably on his approach to the problem. Since the Kent-Rosanoff study paid no attention to speed of response, it may be significant that he was conscious of the speed of response from his second group of 20 words to the end of the experiment. Such consciousness of, or attention to speed, however, may have been purely an effect of the presence of the chronoscope and voice keys. Suffice it to say that

like C, D was aware of time, even though he did not recognize the significance of speed of response in the problem in question.

D, 1st, 3. 15 right.

"More time required, in general, for responses to come. Some words tend to raise almost no response."

D, 1st, 7. 12 right.

"I find that when a response word is long in coming, I tend to search for a definition word rather than any other kind."

D, 1st, 10. 17 right.

"It seems to me that the responses which come fast are more apt to be correct than those that come slow."

D, 1st, 13. 14 right.

"Easier, on the whole, to respond this time, but one took a long time and the final response seemed completely irrelevant. Can't figure out what can constitute a right answer in some cases; some seem pretty queer while others are obvious. I don't see why ten is a response to 'dozen', for example, yet it was correct. (*Dozen–10,* 7, came in the previous 20 responses), 'long–short,' etc., are obviously associated together (*long–short,* 7—remembered from second 20 words), and would often be given, but I am sure that for 'dozen' 11 or even 13, or 'eggs' would be more apt to be right than '10.' Of course I cannot take the time to try for a right answer, but afterwards I have speculated on what is right and what is wrong. . . . Also, having done this before,—the Kent-Rosanoff list,—these correct answers in some cases, seem more modern. The fact that 'cigarette' (*tobacco–cigarette,* 6, remembered from the 10th 20) and such words are correct responses seems to indicate a more modern correct list."

Thus after 260 responses D was fairly sure that some criterion of usualness of response was back of the announcement of *right;* and having recently had a superficial contact with the Kent-Rosanoff study, he took it as a guide.

D, 1st, 15. 10 right.

"I seem to get a faster response if I close my eyes. I find (that) after I respond, I say to myself several words that for me have an association with the stimulus word, but which did not immediately come to the fore."

D, 1st, 16. 13 right.

"For the names of several months I have responded with the word 'month' which was wrong, yet for 'July' 'month' was right, a thing which I can't figure out. Also, I found that I was paying too much attention to the time, so after shutting my eyes, this and other distractions were shut out, and, it seemed to me, my responses were faster."

The names of months used as stimuli were *September, December, February,* and *July,* which fell in the 3rd, 8th, 12th, and 16th 20's. D's responses to them prior to the statement just cited were respectively: *October,* 6; *month,* 10; *month,* 9; *month,* 6. Responses

to the same words in the second sitting, which came a week later were: *October,* 6; *October,* 6; *March,* 5; *Sunday,* 6.

In summary of D's introspections, it is apparent that he was aware of the type of response he was making, and that he commented repeatedly on the reaction time. It is apparent further that he noticed that the fast responses were more likely to be right. His last two statements show an effort for speed of response. Yet the graphic record of scores from his first sitting (Fig. 2) gives no

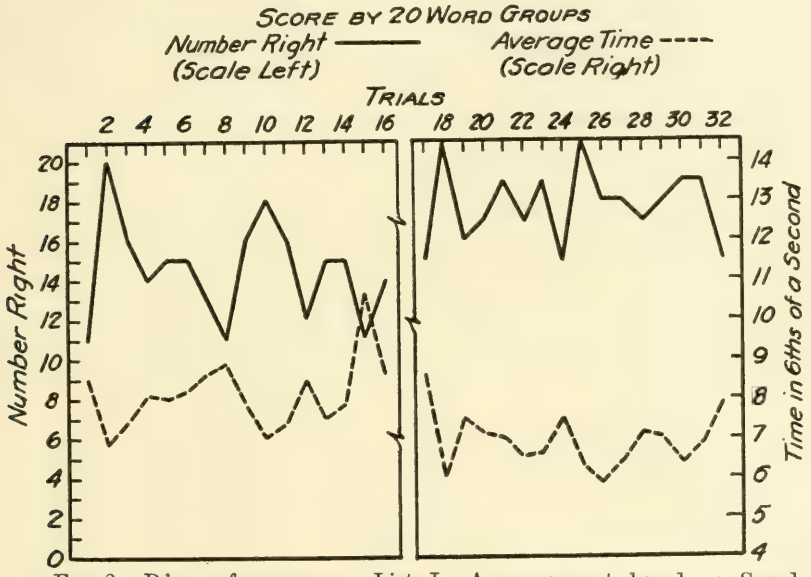

FIG. 2. D's performance on List I. Announcement based on Speed. Data from Tables IX and X.

clear evidence of learning: the performance did not materially improve, nor did it show a consistent trend. It is hard to find any reason for D's failure to improve his scores other than that, although he was aware of, and stated, the solution, he believed that it was still to find, and that his comments about speed of response represented interesting but essentially irrelevant observations.

His performance in the second sitting was much different in character, and was undoubtedly influenced by the fact that between the first and second trials on the Speed Experiment D had solved the Vowels Experiment. Not once in this second series of introspections did D mention the speed of response, although all his introspections were read to him before the second sitting began.

D, 3rd, 2. 20 right.

"... I still can't figure out why some of my responses are right, and others that seem as though they should be right are wrong, and vice-versa. Some of my responses don't seem to relate to the stimulus yet are right. Others seem to relate yet are wrong. If there is another system than just relatively I can't find it."

Thus far D was still operating on the single type of hypothesis, drawn partly from his acquaintance with the Kent-Rosanoff procedure, which had largely guided his responses in the first sitting. From this point, however, his experience with the Vowels Experiment was probably responsible for his changed approach. He considered, without testing them thoroughly, a large number of hypotheses. Most of these depended on the spelling of the stimulus and response.

D, 3rd, 9. 20 right.

"I was trying to find a comparison between the sounds of the two words. It seems mighty queer that I get 20 out of 20 right without knowing the system."

The first sentence of the above introspection is worth noting in view of the fact that D later failed to solve the Rhythm Experiment, which depended on comparing the sounds of stimulus and response.

D, 3rd, 14. 18 right.

"Trying to find some kind of vowel-consonant sequence or relationship between the stimulus and response words; but I am unsuccessful so far. I am repeating my responses (D had slowly slipped into the habit of repeating certain responses: *easy, see, to;* in this group of 20, for example, he said *easy* 4 times, and *ease* once), mainly because I am paying so much attention to the solution that my concentration is not very much on the stimulus and response."

At this point, after 600 responses divided into two sittings, D was responding with little effort, and with improved speed, as can be seen from the lower curve in Fig. 2. If the tendencies which make for quick response are allowed to operate undisturbed, the responses will be quick.

In the case of C, who showed the quickest reaction time to the first stimuli, the tendencies making for speed were disturbed by perfect scores in the early lists, and the speed of response was lessened. In D's case the facilitation of long practice reduced the reaction time; meanwhile D put his attention on the analysis, after the announcement of *right* or *wrong,* of the possible relationships between the stimulus and what had been almost automatic response.

C and D, then, showed opposite trends in their quantitative

scores, were both aware of the speed of their responses, both failed to realize that this was the only factor governing the announcement of *right* and *wrong*. The record from F, the only one of the Ss. to reach an explicit solution of the Speed Experiment, presents an interesting contrast to those from C and D. Up to a certain point F's learning paralleled that of D.

F, 2nd, 1. 12 right.

"Again the system (which) struck me as being the most probable (was) that of relating the part of speech to the reaction. This was attempted, but at times caused long hesitation. At any rate it was unsuccessful. Then I tried using a word which would follow the stimulus word in a usual sentence. This worked, but not always. Then I tried a few opposites. This worked most of the time.

"All through the above, the presence of the timing apparatus led me to hurry. This impeded my reaction time, in that frequent 'blocking' occurred.

"The system, at present, seems to be simply that of calling the 'usual' reaction word as right."

F, 2nd, 2. 16 right.

"A definite attempt was made, in light of my opinion that simply a usual connecting word would be right, to react with the first word that came into mind. In order to further this, I shut my eyes, and left my mind a blank. Some of the resultant words surprised me. Some blocking still occurred, and usually in such cases, the reaction was wrong. The possibilities of similar grammatical construction, opposites, and a reaction word expected as a subsequent word in a sentence, are out. However, any of these may be operative in certain words. The method will be continued."

F was at once the most sophisticated of the Ss. psychologically, and logically the most systematic in his approach to the problems in the various experiments. Yet with this stimulus list he followed the same procedure as E, who had the announcement of *right* based on the sequence principle and D, who had it announced on that of speed. He left his mind a "blank"—a good figure, although hard to define—and let the stimulus control the response. His thinking —his attempted solutions—came after the announcement of *right* or *wrong*, and during the introspection, rather than between the stimulus and response; it will be seen later that the actual solution was sudden.

F, 2nd, 3. 12 right.

"The same system seems operative. Great difficulty was experienced in seeking a reaction word which would be classified as 'usual.' It was usually easy to find reaction words which were either opposite or in a (sequential) relation, such as 'big' for 'little' or 'four' for 'three' (*three–four*, 4). However, abstract words like 'really' (*really–truly*, 25) I found difficult to react to in this manner.

"The response of 'plain' to 'fertile' was wrong (*plain–fertile,* 9). This surprised me, since 'fertile' was O.K. in response to 'plain.' Now it does not seem so surprising in light of the fact that fertile does not 'naturally' follow plain, nor is it opposite, or in any of the usual relations."

In the second of these paragraphs F seems confused, but it is probably a confusion of statement rather than thought. In his first 20 words there was the S–R *fertile–plain,* 6, announced as *right,* and in the third 20—just preceding this introspection— the S–R *plain–fertile,* 9, announced *wrong.* His citation of *little–big* is an inventive example, since *little* had not been presented as a stimulus.

Through his first 60 responses F had evidently much the same idea as D: that any ordinary response would be counted correct. Furthermore, with roughly the same amount of experience in responding to this list, both Ss. had about the same factual basis for reasoning to the correct principle. Such difference as there was between them might be expected to be in favor of D, who had noticed after 40 responses that his responses were coming faster, and who had a somewhat better quantitative record. F's learning, stated in his next introspection, seems purely a matter of insight, rather than of summative reward.

F, 2nd, 4. 11 right.

"The same system seems to be operative. However, the thought struck me near the end of the list, that words given within a short time limit were right. This was deduced from the fact that 'book' was a wrong response for 'page' (*page–book,* 11). This, being a usual response, should be right; and its being wrong might be due to the fact that the time taken to respond was above the limit."

D had merely noted that the faster responses were more likely to be correct, while F saw the significance of the fact, and tested it out in the next 20 responses with some confidence. The difference between the two is clearly brought out by comparing Fig. 2 (D) with Fig. 3 (F). In any case, F's responses after he had verified his hypothesis were distinctive. After responding to words 81–90 with time scores ranging from 5 to 7 sixths of a second, F was sure of himself, and proceeded to make the *experimentum crucis,*—as well as to surprise the experimenter, with the following: *carry–Czechoslovakia,* 4; *decrease–Hungary,* 2; *dative–nonsense,* 2 and *daughter–Hitler,* 2. Further introspections were unnecessary, but F explained spontaneously that he had decided in advance on his responses, and had watched E's lips rather than listened for the stimulus. In his remaining 6 responses F followed instructions, and was able to get

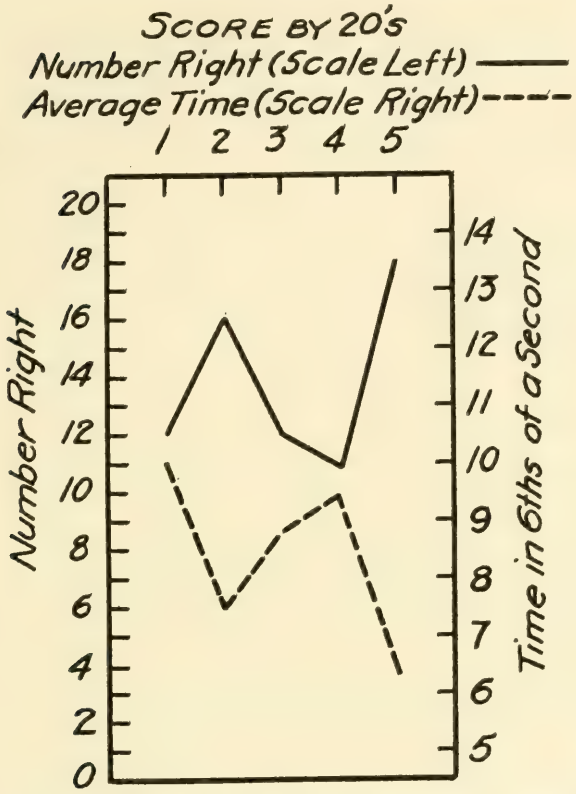

FIG. 3. F's performance on List I. Announcement based on Speed. Data from Table IX and X.

only 4 right, the two errors were: *firmament–firmament,* 12; and *gnash–Ford,* 9. These were consistent with the blockage reported in his first two introspections.

THE RHYTHM EXPERIMENT

Tables XI and XII, and Fig. 4 present the results of the rhythm experiment. It will be seen that only two Ss., B and C, arrived at complete solutions. F reached a partial solution after his sixth 20, but never arrived at a full statement of the rhythm principle. In his 15th 20 he responded throughout by repeating the stimulus, which of course met the rhythm requirement. G's high score on the 8th 20 was due to the same pattern of response. In each case the responses were announced as right with no further comment until the full twenty responses were given. Both Ss. were then asked to continue, with the requirement that they respond with something other than the stim-

TABLE XI[a]

NUMBER RIGHT, BY RHYTHM PRINCIPLE, LIST II

20 Word Units	*Ss.*						
	B	*C*	*C*[b]	*D*	*E*	*F*[b]	*G*
1	5	9	13	6	6	9	6
2	*9*	9	*16*	8	5	7	7
3	*14*	10	19	12	14	9	14
4	*16*	6	*16**	8	9	5	6
5	*14*	7	16	10	4	5	8
6	18	7	19	10	11	*16*	11
7	*19**	10	20	13	13	18	14
8	20	13		13	11	18	*17*
9		9		9	10	18	7
10		9		7	9	*12*	2
11		*12*		8	10	15	7
12		14		8	5	8	7
13		*17*		11	11	*17*	7
14		15		12	8	*18*	4
15		17		11	10	20	6
16		12		10	6		9

[a] *Cf.* Note a, Table VIII.

[b] C and F had two sittings each, the break coming in C's case after 320, and in F's after 200 responses.

TABLE XII[a]

NUMBER RIGHT, BY SEQUENCE PRINCIPLE, LIST II

20 Word Units	*When Announcement to Ss. Was Based on Rhythm*					
	Ss.					
	B	*C*[b]	*D*	*E*	*F*[c]	*G*
1	15	7	4	10	5	1
2	*15*	8	5	12	13	0
3	*20*	7	9	17	10	0
4	*14*	10	7	10	7	0
5	*16*	11	4	13	6	0
6	10	7	3	11	*3*	1
7	*12**	5	6	9	2	0
8	12	7	5	13	0	0
9		7	11	13	2	6
10		10	10	16	*1*	5
11		*7*	8	14	0	2
12		4	5	13	0	3
13		*6*	1	16	*3*	6
14		4	5	12	*1*	5
15		6	3	18	0	
16		3	6	11		

[a] *Cf.* Note a, Table VIII.

[b] C's last 140 responses were not rescored.

[c] *Cf.* Note b, Table XI.

ulus word. G did so, and his score dropped. F refused; he had already spent roughly two and a half hours on this problem, was thoroughly discouraged, and said that he was sure that the full solution would involve several hundred more responses.

The introspections by the two Ss. who solved the problem will be given first.

B, 3rd, 2. 9 right.

"I seem to have made correct responses by using the stimulus word as an adjective, but this hardly seems to be the case with *ship–crew* (*crew–ship*), and *freeze–cold,* which I think were scored right. An example of the above statement: *ladies–meeting.*"

B, 3rd, 3. 14 right.

"Will try number of syllables on next list."

B, 3rd, 4. 16 right.

"The word associated with the stimulus word seems to require the same number of syllables."

B, 3rd, 5. 14 right.

"The word must have some associative meaning, and must be of the same number of syllables. On at least two words I realized I was wrong as soon as I had said the word, because of the incorrect number of syllables."

B, 3rd, 7. 19 right.

"I think the emphasis should be on the same syllable in the reaction word as in the stimulus word. It is hard for me to recall words in the series of more than one syllable; but as I remember, *enjoy–living* was wrong. This gave me the clue for the syllable emphasis!"

Two things, both found in other cases as well, deserve comment in B's record. One is the presence, along with the correct hypothesis, of a second, completely irrelevant but not wrong. In B's case, and possibly in most such cases, the irrelevant hypothesis came first; when a solution was not reached using this hypothesis alone it was retained in modified form rather than discarded.[2] Influenced by the Sequence Experiment, B used the stimulus as a modifier, and gave responses which when rescored on the Sequence basis, as shown in Table XII, had the following number right in successive 20's: 15, 15, 20, 14, 16, 10, 12, 12. Even after being fairly sure that the response word must match the stimulus in number of syllables, B was explicit that it "must have some associative meaning."

Second, it is interesting to notice what slender grounds B had for the tentative statement made about emphasis after responding to her 7th 20 words. Repeatedly in this series of experiments Ss. stated

[2] A familiar literary example of this tendency is found in Lamb's story of the Chinese who would burn their houses down to roast a pig, because their first roast pig had been salvage from a fire.

hypotheses—and rejected them—on what seemed logically inadequate grounds. In the 20 words in question B had responded to only three words of two syllables, as follows: *baby–bottle, farmer–country,* and *enjoy–living.* The learning depends here not only on the reward and punishment in hearing "right" and "wrong" but in selecting the differentiating aspects of the two types of response. In the examples cited, the two correct responses were words beginning with consonants and ending with vowels, in both of which respects they matched the stimuli; the incorrect response, beginning with a consonant, was to a stimulus with an initial vowel. This would seem a reasonable differentiating principle, and it was adopted by one S. who had solved the vowels problem, before attempting this one. In the present case, B having previously solved the parts of speech problem, it would seem just as natural to notice that the wrong response stood in a different grammatical relationship to the stimulus than the two right responses. But B had apparently discarded such a possibility after the first introspection cited above, and turned her attention to the number of syllables; *i.e.*, although she was still giving some attention to the symbolic, she was thinking especially of the purely auditory aspects of the words. This being so, the selection of accent as the second controlling principle is not hard to understand.

C's solution, especially insofar as it dealt with the placement of accent, was slower than B's, although based on a more systematic approach. The Rhythm Experiment was his second, the first having been the Vowels Experiment, calling for numerical response. It is interesting, therefore, to observe that he was very early aware that many of his responses were sequents of the stimuli. The rescoring of his first 320 responses on this basis is shown in Table XII.

C, 2nd, 1. 9 right.

"My first response was an opposite of the stimulus (*appear–disappear*), and was called wrong. Most of the correct ones were related in the same meaning as the stimulus. As the (responses) are uttered without first thinking, corrections will have to be made in my mind unconsciously."

C, 2nd, 2. 9 right.

"The correct answers still seem to be logical sequences of the stimulus, but not opposites."

C, 2nd, 3. 10 right.

"I'm puzzled by having *act–to* (sic) called right, but *belong–to* wrong."

C, 2nd, 5. 7 right.

"Some correct answers seemed to follow their stimuli, such as, *kiss–me, list–this, note–this.* The synonym *govern* for *rule* was wrong."

C is clearly aware of the sequence principle, and of its contrast with response by synonym or antonym. After commenting in one of the intermediate statements on the fact that opposites are wrong he says:

C, 2nd, 10. 9 right.
"Opposite *somebody* was correct for *nobody.*"

This observation of an exception to a previously stated rule may have helped in arriving at a correct generalization. In his next two introspections C gives a partial statement of the principle underlying the assignments of rights, and gives an illustrative comment on the gradual quantitative improvement even after the correct principle is recognized.

C, 2nd, 11. 12 right.
"The correct answer seems (to) coincide in syllables with the stimulus."

C, 2nd, 12. 14 right.
"Although I'm trying to follow the above system, often the first word which comes to mind is at variance with what I wanted to say."

C, 2nd, 13. 17 right.
"I have fallen into the habit of repeating stimuli in (the) plural, which usually gives the same number of syllables, but sometimes the plural answer has led into an extra syllable—*wage–wages.*"

Including within this habit pattern any addition of an *s* to the stimulus word, C had made one such response in the first 200; in the next three 20's, including the one just cited, he made 4, 7, and 10 respectively. After commenting on the tendency, he added the *s* in four of the next 20 responses, and not at all in the remaining 40 of the first sitting. Along with this tendency there was another, not remarked on by C, of giving a response similar in sound to the stimulus, *e.g., proud–pride, teeth–tooth, grove–groove, berry–cherry.*

A striking feature of the introspection after the 13th 20 is that it is mistaken in fact. Up to this point C had not had the stimulus *wage;* he had given the response *wages* to the stimulus *labor* in the 9th 20, which was announced as right. The only wrong response of this type was *disease–diseases,* which came in the 12th 20. Although, as was shown in the previous paragraph, C abandoned this tendency shortly after stating its existence, yet when the stimulus *wage* was presented eleven words later, the response was *wages.*

C, 2nd, 14. 15 right.
"Same trouble as page 13, plus the difficulty of finding a suitable substitute for such plural words which hold an extra syllable."

During this 20 there was one occurrence probably significant in C's eventual learning. Already aware that the response had to match the stimulus in number of syllables, C responded to *colony* with *Oneida,* which had a wrong accent. He questioned the experiperimenter's announcement of wrong, but was assured: "colony-Oneida, is wrong."

Through the remainder of C's solution there are only two points of interest. During the second 20 of the second sitting he made a wrong generalization from the fact that *nineteen* was wrong for *eighteen,* and said the response evidently had to begin with the same type of letter—vowel or consonant—as the stimulus. As in other cases, this irrelevant part of his solution was retained after the essential aspect of accent was discovered. We find him saying:

C, 2nd, 20. 16 right.

"In addition to having the same number of syllables, and beginning with vowel or consonant, I think it is necessary to put the accent on the same syllable. The word *perform* can't be used for all two syllable words."

The older, and irrelevant idea is stated with certainty, the recently discovered and essential one only tentatively. C preserved the initial vowel and consonant agreement through the whole group of 20 words. There were in this group 10 two-syllable words, which drew three significant responses: *prison–perform, ribbon–perform,* and *shepherd–boyhood.*

This introduces the other point of interest in C's later learning: the amount of system shown. These two type responses, for the two accent placements, were used once each in the following 20 words: *perform* correctly for *divide,* and *boyhood* incorrectly for *enemy.* In these two cases the connection in meaning is slight, and the association was apparently controlled by accent alone. The other responses to words of more than one syllable are worth citation. For convenience in discussion the order in which the stimuli were presented has been changed.

	Stimulus	*Response*
I	contain	contend
	prepare	prepared
	heaven	heavens
	party	parties
	service	servant
	member	lodges
II	quiet	silent
	famous	well known'
	natural	phenomenon
	important	safer

These fall into two groups: I comprising noun and verb stimuli, II the adjective stimuli. The characteristic response to stimuli in Group I is one which changes the stimulus, but does so as little as possible. C has clearly learned to react to sound rather than the symbolic value of the stimulus; in this problem the sound *is* the meaning. The one exception (*member–lodges*) is probably only partly so, unless it is going too far into conjecture to say that without awareness of the number of syllables as a controlling factor C's response in this case would have been in the singular. These six responses are all correct.

The four adjective stimuli, by contrast, elicit only one correct response, a synonym. There are also an incorrect synonym, an incorrect sequent, and an unclassified response—*safer* for *important.* This is reluctantly left to the psycho-analysts to interpret: It violates all three rules of which C had stated up to this time, and does so without the pull of any strong connections of meaning or habit known to the experimenter.

Thus although C had hit on the device of responding to various stimuli with the same word, he used it only sparingly for a time, but he used it consciously.

C, 2nd, 22. 19 right.

"I've forgotten about the first letter, and am concentrating on the number of syllables and where the accent falls. Saying 'boyhood' for 'period' was pure carelessness. Before I began the list I decided to use 'boyhood' for two syllable words with the accent on the first; and for accents on the second syllable I used 'perform.' "

This convenient rule was followed in the main, nevertheless in the 20 words preceding and the 20 words following this statement we find such responses as *devil–devils, product–products,* and *uncle–uncles.*

D reported on this experiment after he had responded to the other four lists; it will be recalled that in an earlier experiment he had stated the essential hypothesis for this one: that the sounds of the stimulus and response should be compared. In view of these facts, perhaps the most important thing to note in D's record is that he did not learn.

E had this experiment as her first. Her introspections support the quantitative record: she never once gave any attention to number of syllables or accent. She states repeatedly her opinion that the usual responses are the right ones, and that she does best when she responds with the least conscious effort or choice. Her whole series

of introspections should be considered as continuous with, and an introduction to, those already cited in connection with Sequence Experiment. Since this group came first, and since they give clear expression to certain aspects of the stimulus words which control the responses, they are worth considering.

E, 1st, 1. 6 right.

"Words like *appear(–mouse)* were more difficult to make associations with than words like *eight(–nine)*. I found that my most recent experiences influenced my response on words that did not have definite associations (as) 'eight' has. An example of this would be the word *common*—my response was *noun* because in the past week I have been teaching common nouns."

E, 1st, 2. 5 right.

"In this group I could see even more definitely how my apperceptive background has influenced my response, especially in the word *manufacture (–radios)*."

E, 1st, 6. 11 right.

"Probably the most interesting thing about this group of words was the word *fame(–note)*. When given this stimulus I thought of all the possible kinds of fame, and the abstract meaning of the word itself, but no definite word would come to mind. Finally I said the word *note,* which was absolutely the first word that came to me, and also the correct one."

E, 1st, 10. 9 right.

"Again I find myself, in spite of all previous experiences, trying to select the correct word. When the word *hid(–it)* was given I thought *it,* but was still going to select a word rather than give the first one that came to me. With the word *virtue(–truth)*, I am afraid that was purely selection for I felt as though I knew the correct answer but just couldn't say it."

E, 1st, 12. 5 right.

"In this list I can definitely say that I again tried to make selection. For instance, the first word, *attention(–pay)*: what I should have said was *please.* . . . I have also noticed that even though I give the first word that comes to me as my response, it is not always correct, and often I can tell that it won't be. For example, the stimulus *cottage* caused me to say *small,* for I was thinking of the musical selection. . . . My recent experience and apperceptive background influence my response so that it is not always the correct one, though the first thought in mind."

E, 1st, 13. 11 right.

"Probably the most interesting experience I had with this list was from the stimulus *bone(–meal)*. My first thought was *cancer,* for . . . my father recently died with cancer of the bones. However, I knew this was purely a personal reaction, so I ruled this out, and then selected the word that would naturally come to me if I hadn't had this recent experience, which was *meal,* and the correct one."

Through the whole series of 320 responses to List II, E believed that the correct response was the "normal" one, and that she could

give it best by making as little conscious selection as possible. Her examples make it plain that for her the normal response was one which fitted the sequence principle. Announcement of right was made to her on the basis of rhythm, but she considered the wrongness of *common–noun, manufacture–radios, attention–pay, cottage–small,* as well as the anticipated wrongness of *bone–cancer,* as due to personal factors—recent experience or a failure to follow instructions as with the stimulus *attention.* Now when her responses to these ten stimuli, which she selected as typical, are rescored for the sequence principle, we find that one verb and three abstract nouns drew wrong responses. Of the six sequential responses, two were to ambiguous stimuli treated as adjectives, two were to transitive verbs to which she gave objects, and two were highly specific uses of words best classified as common nouns. Even her rejected response, *bone–cancer,* uses the noun as adjective.

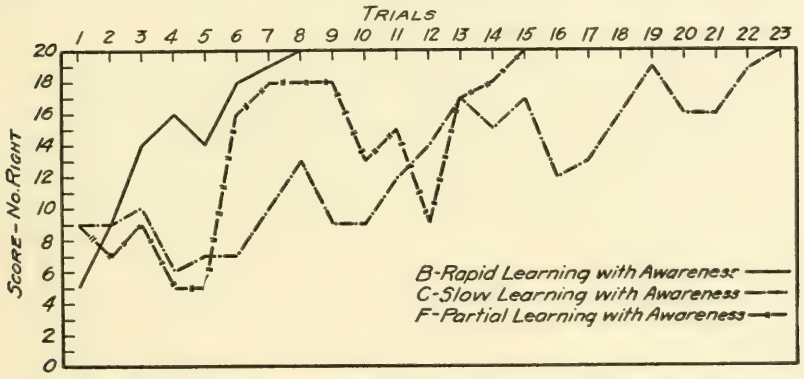

FIG. 4. Performances on List II. Announcement based on Rhythm. Data from Table XI.

E's belief that she knew the solution, and need only apply it, explains sufficiently her failure to learn the rhythm principle. As to the sequence principle, which she was trying to apply, Table XII makes it clear that she did not materially increase her tendency to make this type of response.

Although he reached a partial solution by adopting the device of repeating the stimulus word as a response, G's work on the Rhythm Experiment has little other interest. He started with the idea that the grammatical classification of the words was somehow involved, and he continued through 140 responses testing out various relationships based on it. He was then told that there was "no progress to be made by considering parts of speech." For his next

responses he repeated the stimulus, and reported as follows at the end of the 20 words.

G, 2nd, 8. 17 right.

"Every repetition was correct; all variations, noun to adjective, etc., failed."

The three variations, coming on the 6th, 7th, and 13th words, were: *wire–wiry, advise–advisable, consist–consistent.* Even with specific negative instructions G continued to think in terms of grammatical relationships. At this point he was instructed to respond with some word other than the stimulus. He did so for another 160 responses, but without appreciable progress toward learning.

One striking feature of F's performance on the Rhythm Experiment includes the prolonged persistence of an irrelevant hypothesis, of the sort already commented on. Another aspect of F's work with the rhythm principle, which is only partly revealed in the introspections, is that it was highly emotional, and cost much effort. A third, was his use of the stimulus word as a response. His adoption of this device, however, came after his awareness that the response had to match the stimulus in number of syllables, and is thus more in line with C's responses by inflected forms of the stimuli, which was also adopted after partial learning, than with G's repetitions of the stimuli. Before coming to the experiment, F had solved the parts of speech, speed, and vowels problems in that order.

F, 4th, 1. 9 right.

"Attempt was made throughout this list to respond as per directions, *i.e.*, simply with the first word that entered my mind, in the hope that such response would yield a great enough spread of possibilities so that some leads could be deduced from the right answers. . . . After . . . the previous experiments, I feel that given enough lists, without employing directly any analytical system of discounting possibilities, I could nevertheless at some point gain insight into the system by a sort of 'subliminal hang-over' of rightness and wrongness of certain types of response."

F, 4th, 3. 9 right.

"Using a hit-or-miss approach rather than attempt to try a system has the effect of making it more difficult for me to remember what words were right. At one point in the list, I felt for some reason that the system varied for nouns and verbs. On reflection, this is a strong possibility, since only nouns and verbs appear in the lists. Part-whole relationship for nouns, sequential relationships for verbs was considered. This does not seem to apply. Other systems will be tried, keeping in mind the strong possibility of different approaches to nouns and verbs."

The general approach used by F to this point would seem to favor learning without awareness; but he shifted to the more active

approach of forming and testing hypotheses. His memory was at fault when he stated that the lists included only nouns and verbs; it was soon corrected.

F, 4th, 4. 5 right.

"Appearance of the words *whence(–where-from)* and *utter(–complete)* eliminated the above classification. Having met these words, my reaction was a feeling of hopelessness."

F, 4th, 5. 5 right.

"My reaction at the present is one of disgust with myself. No method has been applied except a sporadic attempt to verify those possibilities which I have already discounted. . . .

"It now occurs to me that perhaps my general orientation has been faulty in attempting to correlate the meaning or the structure of the reaction to the stimulus word. A host of possibilities exist which depend upon less apparent but more subtle attributes of the stimulus words. These will be tried out on the following list. Such possibilities are not precisely clear to me at the moment, (but they include) the appearance of the same or different initial letter in the reaction word, the same or different number of consonants or vowels, etc."

F, 4th, 6. 16 right.

"On the first word (*crush–do*) I tried the possibility of employing the initial letter in the reaction word in alphabetical sequence. After a few words it struck me that the list was being given in more or less alphabetical order. Due to my previous orientation (F is referring to introspections made in the course of the Vowel Experiment), it struck me as being very interesting that I did not perceive this alphabetical order (until I used) an alphabetical system. . . .

"A modification of the system of alphabetical order in the initial letter seems to be the necessity of giving the same number of syllables in the reaction word. This worked out in the latter part of the list, and will be continued."

We have here the irrelevant principle, and an incomplete correct one; but the irrelevant one came first, and was not eliminated. Since the learning can be located fairly definitely within these 20 responses, it will be helpful to consider F's wrong responses, which were to the 2nd, 4th, 7th, and 10th words: *devil–enough, empire–freeze, frighten–go, indicate–junk.* Through the remaining 10 words the responses matched the stimuli in number of syllables and accent; there were 6 stimuli with 1 syllable, 3 with 2, and 1 with 3.

Responses to the next 140 stimuli were within the same general pattern, with F trying various modifications of his rule in the effort discover the other principle which he was certain was involved. In one group of 20 words (the 12th, 8 right), he purposely violated the syllables rule in order to verify it, but he preserved the initial letter relationship: *judgment–kinetic, log–mismanagement, mistress–neophyte, oblige–philosophical.* Some new steps in the learning then occur, which can best be shown in his words.

F, 4th, 13. 17 right.

"A chance deviation from the above system on the very first word being right, my entire system was seen to be faulty. The next step in analysis, then, was the answer to the question: how could I have been giving so many right answers using the above system? It followed, since the above-mentioned error was the word *ox* for *moon*, that the same number of syllables was the correct system, with the added possibility, since I had been giving right answers in alphabetical order, that vowels had to follow consonants. (The second and third items in this group were *nest–ox*, and *offer–beeswax*, both correct.) This was poor deduction on my part, since the only thing I had to go on was an example in which a vowel followed a consonant. The only system which remains in my analysis is the same number of syllables with *different* initial letter."

The italics are the experimenter's. After the surprising and annoying announcement of right for *moon–ox*, F insisted on having the stimulus repeated so that he could be sure he had heard right. His reasoning up to a certain point was good, and when he got beyond that point he himself called it bad. Yet he persisted in attending to the irrelevant initial letters.

F, 4th, 14. 18 right.

"Using this system I made an error which was due to my faulty division into syllables. . . . I decided to test the validity of the necessity for a different initial letter. This was discounted. Not until the last word did it strike me that since only the same number of syllables was necessary, it might be permissible to simply repeat the stimulus word."

As a matter of fact, the first error came on the tenth word, and the matched initials were tried only on the nineteenth (*courage–cleavage*). F was not misled by the perfect score when he used the stimuli as responses and he says in his final introspection, after the 15th 20, that a "host of possibilities" existed; he was certain only that the stimulus and response had to be matched in number of syllables, and he would neither speculate on nor search for the other principles which might be involved.

The Parts of Speech Experiment

Table XIII presents the results from the parts of speech experiment, in which the correct principle was stated by four of the six Ss. who attempted it. It will be remembered that in this experiment the stimulus list included only 100 words, so that Ss. B, C, and D, went through the list three times each, with the consequent possibility of showing improved scores without any learning of the principle of classification. It will be remembered also that in each 20 words there were 9 nouns, classified as 1; and 4 verbs, classified as 2; with the remaining 7 words classified as numbers 3–6 in the

TABLE XIII[a]

NUMBER RIGHT, CLASSIFICATION BY PARTS OF SPEECH, LIST III

20 Word Units	*Ss.*					
	A	*B*	*C*	*D*	*E*	*F*
1	2	5	6	4	*7*	*0*
2	3	*14**	7	2	*11*	*9*
3	3	15	6	2	*17**	*6*
4	2	11	3	4	16	*11**
5	5	16	6	2	15	14
6	8	17	3	1	17	18
7	*6*	17	*11*	1		19
8	3	18	5	*6*		18
9	*19**	15	6	4		20
10	17	19	9	2		
11	16	19	10	6		
12	16	18	12	1		
13	18	18	*10*	4		
14		17	13	3		
15		19	15	4		

[a] *Cf.* Note a, Table VIII. In this case the asterisk is inserted when the S. named correctly at least 2 of the 6 numbers used in classifying.

ratio 3 : 2 : 1 : 1. These two aspects of the stimulus list had little or no bearing on the records of the Ss. who stated the correct principle, but they do affect the records of C and D, who did not.

C, who did this experiment as his fourth, attempted his solution by counting the number of syllables, the number of vowels, of consonants, of different vowels, of vowels followed by hard consonants, and the like. He noticed also the position of the accent in the stimulus word. The influence of his previous solutions of the vowel and rhythm problems is apparent. The improvement in score,—from 28 right in the first 100 responses to 60 right in the last 100, is explained by the introspections.

C, 4th, 5. 6 right.

"For the first time, I have said a number above 3 and been right, *wherever*–4."

C, 4th, 7. 11 right.

"Some of the words I (answered) correctly were from pure memory, such as *frog* and '*depth.*' "

C, 4th, 9. 6 right.

"A good many of the words on the previous lists appear again, but since I didn't know the answers then, they are of no help now. However, the few I do get right are from memory only."

C, 4th, 11. 10 right.

"It seems that the lists are rotating. In all my guesses I have yet to hit

on a word for 5 or 6, and so I wonder if they are not included just to make the guessing more unsuccessful.''

In brief, C learned something about the stimulus list, that it contained unequal numbers of words of the various classes; but he learned nothing of the classification. It is interesting that his first 100 responses, which he believed were made largely at random, included 26 responses of 1, and only 3 each of 5 and 6.

D's number preferences were quite different. He gave only 3 responses of 1 in his first 100, and in the entire 300 responses the distribution was as follows:

Response	*Frequency*
1	13
2	53
3	119
4	87
5	21
6	7

More than $\frac{2}{3}$ of his responses were thus centered on the two numbers 3 and 4, which made up only $\frac{1}{4}$ of the stimulus list. D had this as his fourth experiment, the only previous solution being with the vowels. His attempted solution of this problem was along the same line, with the addition of one other type of approach,—the hypothesis that the numbers were assigned to the words according to their serial positions in the 20 word group. After the 7th 20 he was instructed that he would make no progress by analyzing spelling, but he reverted to such analysis on the 14th 20.

D, 4th, 2. 2 right.

''Tried position of the words in the series that time, such as one might (be) 3, the next 4, etc., but no results. When I get one right I disregard the next few words, and try to find a relationship between the number and the word.''

D, 4th, 4. 4 right.

''I am still guessing. None of my *schemes* of counting have worked, but I can't think of any relationship at all.''

D, 4th, 6. 1 right.

''Have counted the consonants and the number of letters, tried to divide them by 2 or 3. If I get a five letter word and say 5, it's wrong. If I get a six letter word and say 3 or 6 it's wrong. I can't think of anything else to count.''

Then, just after the negative instructions:

D, 4th, 8. 6 right.

''Got three right that I remember, but I am still in the dark. (Only two

of D's rights here had been right on the first presentation.) The last hint leaves me with no ideas except position in the list, which I can't make work."

D, 4th, 11. 6 right.

"Got the first one right, added 2 and got the second right (5), then added 2 and got the third right (1), but the fourth (3) was wrong. Tried the same thing later on with no success."

D, 4th, 14. 3 right.

"I am now looking at first and last letters. I don't know whether the hint was not to do this or not. Only thing I can think of."

The striking thing about these introspections is not that D couldn't "think of anything else to count," but that he didn't think of anything else but counting. Failure to succeed on hypotheses arrived at *a priori* led him only to try the same hypotheses in more complex applications. In view of the many serial patterns which might be built up among 20 responses numbered from 1 to 6, D would have been unjustified on the grounds of formal logic in inferring from a single negative case that the answer did not lie in any serial arrangement of the responses. But the learning would have been better had he done so. The performance contrasts sharply with the successful learning of certain other Ss., who were more varied in their approach, if less thorough in testing their hypotheses.

Among the Ss. who solved the parts of speech problem there were two steps in learning: first, awareness that a grammatical classification was involved, and second, elaboration of the complete number code. The second step was not completed in every case; and as explained in the note to Table XIII, awareness of the solution is marked if at least two of the six necessary statements were made. Classification of nouns and verbs came first in three cases: this is probably due not only to the fact that they were most numerous in the stimulus list, but to the fact that the inadequacy of the grammatical training which these Ss. had received made the other parts of speech difficult to identify. B, for example, after stating the proper numbers for nouns, verbs, adjectives, and adverbs, twice classified *costly* and *stormy* as adverbs. Three of the Ss. had difficulty in recognizing *electric* as an adjective; F did so after much delay, but B called it a noun, and E an adverb.

A's solution had little of special interest. His introspections were meagre, but enough to show that he tried out, testing them all inadequately, classification by number of letters, number of syllables, long and short vowels, soft consonants, rhythmical patterns

of stimuli, and numbers assigned to initial letters according to their position in the alphabet. After the third 20 responses he suggested that Grimm's Law might be involved; this was repeated after the 4th 20, with the statement "probably Grimm's Law." This was read aloud as he wrote it, with enough certainty to prompt the negative instructions that Grimm's Law was not involved, and that no solution would be reached by attending to the individual letters. In spite of these instructions, A continued in the 5th 20 to carry on phonetic analysis; the negative instructions were repeated, and A insisted orally that short *e* was significant, since 2 was right for *fled* and *vex*. He then became equally positive that the rhythmical patterns of the words defined the principle; having considered that solution during his 5th 20, he was so certain after the 6th that negative instructions were given.

Only 15 of A's first 100 responses were right, and it was not until the 7th 20 that he had the basis of a solution, although from the first he had been trying to remember correct responses, and to generalize from them.

A, 1st, 7. 6 right.

"Parts of speech—won't work. What have *salary, mystery, papa, priest, ticket, frog,* (in common)? 2: *tempt, vex, fled.*"

Although with these facts he says that classification by parts of speech won't work, his attention has been on this aspect of the stimuli, and part way through his 9th 20 he remarked that *distinct*–3 and *gradual*–3 were both adjectives. At the end of this group he presented his solution in outline as 3–adjective, 1–noun, 2–verb, 4–preposition, 6–pronoun, 5–adverb. With the 15th 20 he had arrived at the full solution except for the omission of pronouns, properly classified with the conjunctions as 6.

F met this problem as his first, and hit on the correct hypothesis after his first six responses; yet his learning was slower than that of B and E. This may have come from using too systematic an approach—or we might better say from devising a systematic approach which he was unable to use. F responded to his first 20 words with the numbers 1–6 in order, followed by 14 responses of 5. In the second 20 he responded uniformly with 1.

F, 1st, 1. 0 right.

". . . Since none of the numbers was right, the possibility of a random rating was dismissed. Also, I felt that there was a 'skunk in the woodpile' since a system should include a certain amount of rights on number 5. This leads me to the possibility that perhaps all the words in the list were right for a particular number, not 5. This will be further determined in the next list.

"The possible basis of the system which I had expected after hearing the first 6 words was a correlation between the part of speech of the stimulus word, and the rightness of the reaction number. This possibility is proven to be out."

Note that F is twice mistaken in his reasoning here: he needed no further proof to know that the same number was not applied to all words, and he had not disproved the parts of speech hypotheses.

F, 1st, 2. 9 right.

(1 was used for all responses.) "Words right are: *depth, blacksmith, instrument, inquire, salary, money,* and three others which I have forgotten. In further attempt to develop a system, I responded with the same number, with the intention of analyzing the correct responses. I made no attmept to do so while responding, being content merely to remember the right words. In this I was only partially successful. While responding I also noted the ordinal position of the right words, but was unable to make any deductions from this. Present analysis of the right words also leads to no deductions. Random right and right and wrong . . . is still a bare possibility."

The serious fault here was not the gap in memory, but remembering a wrong answer (*inquire*–1) as right. Nevertheless F continues to consider parts of speech.

F, 1st, 3. 6 right.

"At the beginning, I tried again to develop a system by parts of speech. This again did not work out." (F then outlines several possible numerical relationships which he had considered.)

Why F's "system by parts of speech" did not work out, is an interesting speculation in view of his first 9 responses among the 3rd 20. These were:

1.	borrow–2	R	
2.	canal–1	R	
3.	delicate–3	R	
4.	discovery–1	R	
5.	from–4	W	
6.	glorious–3	R	
7.	hospital–2	W	distinctly puzzled by announcement
8.	joy–2	W	
9.	maker–3	W	

Thus, after being right on two nouns, two adjectives, and a verb, F names two nouns in succession as 2, and tries 3 for a third.

F, 1st, 4. 11 right.

"In this list I again started to try to develop a system from the number of letters in the word, but was unsuccessful. Then I reverted to the grammatical possibility. This seemed to work out, with nouns right for No. 1, verbs for No. 2. When adverbs, adjectives, and pronouns were tested according to this, the system upheld. If I remember correctly, prepositions are right for No. 3."

From here on F was in no doubt about the correctness of his system as a whole, and in the next 100 responses worked out correct statements for numbers 3–6.

The solutions by B and E were similar. In each case the correct hypothesis was stated early, with the bulk of the effort put on working out the details of the classification.

B, 2nd, 1. 5 right.

"I tried to find some reason for the numbers. On the first success I tried classifying words by parts of speech. I think this idea influenced my responses for the first group. The word *easily* was #4, and I used this as a key for #4 from then on."

B, 2nd, 2. 14 right.

"I followed the same line of thought, and found nouns to be #1, verbs #2, but was unable to classify other parts of speech."

B continued through a total of 300 words without fully perfecting the classification which she became aware of on her first success—the sixth word presented. She was making no use of number 6 until instructed, after the 11th 20, "you are allowed to classify from 1 to 6." Even then, she used 6 in only two of the remaining four groups. The principle was correctly stated for nouns, verbs, adjectives, and adverbs; but only the verbs were consistently identified correctly.

E performed this experiment as her third, after failures on the Rhythm and Frequency Experiments. In her work on the latter experiment she had not tested out the principle of classification by part of speech, but her introspections had mentioned nouns.

E, 3rd, 1. 7 right.

"On the basis of the experiment before this, I tried to classify the words under the different numbers as I had done before. I placed the common nouns like *ticket*, under 1, and grouped others accordingly. It was difficult to remember that there was a choice of 6 numbers. . . ."

E, 3rd, 2. 11 right.

"This time I tried definitely to place each part of speech like noun, verb, etc., under a certain number. As yet, I haven't found the correct number for each, although as I have said before, I know definitely that nouns belong under 1."

Two facts about the stimulus list for this experiment seem adequate to explain why E, after a lapse of four days, so quickly adopts a correct hypothesis which would have been reasonable in the earlier experiment, as well as within the context of her thinking. In the first place, the stimuli for the parts of speech experiment were so chosen as to be about equally common. Second, they were chosen to eliminate all words of ambiguous grammatical classification. From

E's introspections on the frequency experiment, which will be cited below, it seems likely that when she mentioned the "most common nouns" in her first introspection here, she was more interested in the fact that the words were common than that they were nouns, *i.e.*, she was approaching a solution to the frequency problem, which she had partially solved. With the changed character of the stimulus list, however, her attention was given to the fact that although all the words were common, only some of them were nouns.

E, 3rd, 3. 17 right.

"This time I have affirmed some of the classifications I was not certain of the last time. That is, I have placed verbs under 2, adjectives under 3. I am not quite sure as yet of the others."

The full classification was correctly stated after the 6th 20. The fact that E never got more than 17 words right out of the 20 was explained spontaneously by her as due to mistakes "made in classifying the words."

The Vowels Experiment

Table XIV gives the results of the Vowels Experiment. This presented, if not the easiest, certainly almost the easiest problem of the series. A difficulty arose in some solutions, however, similar to that in the parts of speech experiment: some of the Ss. were sure enough of the criterion for rightness, but were not certain which letters were vowels.

In view of the fact that the Ss. received the problems in different order, and the fact that the problem involved in this one was solved by Ss. who had it in every position in their series from first to fifth, it is worth trying to discover why it should have been relatively easy. The explanation may be that while all three of the number code experiments suggest, by the very type of response called for, that counting *something* will be a useful approach, this is the only one of the three in which counting is involved. In the rhythm experiment, conversely, the instruction to respond with another word diverts the attention from the essentially numerical nature of the correct response.

H, the only S. not to learn in this experiment, had a performance characteristic of poor learning in the entire series: there was a paucity of ideas, and persistence in testing out such few hypotheses as were formed, extending in this case to the retention of a wrong hypothesis after specific negative instructions. The introspections below will be ample to show these tendencies.

H, 1st, 1. 3 right.

"The first time I picked the number which corresponded to the letter. For the letter *a* as in *am*, I said 1. Later, when I saw this was wrong, I picked the number corresponding to the number of letters in the word. For *glad*, I said 4, etc."

Attentive within his first 20 stimuli to the number of letters in the words, H immediately shifted to a hypothesis based on serial position; and except for intervals of purely random guessing he retained it through the next 200 stimuli, in spite of specific negative instructions after the 7th 20.

H, 1st, 4. 4 right.

"The fourth trial I used the same system, trying to count the number of the word, and associate it with the number in the corresponding position."

H, 1st, 6. 7 right.

"This time I saw there was an order of arrangement: 1, 3, then another number which I couldn't determine. After each 1–3, there was a 2–4."

The responses on which this observation was based were as follows, the correct ones being in italics: 1, 4, *3*, 4, *1*, *3*, 5, *1*, *1*, 3, 3, 4, *2*, 4, 4, 3, *3*, *2*, 4, 4. There was thus one correct and one incorrect occurrence of the 1–3 pair, no correct occurrence of the 2–4 pair, and no incorrect occurrence adjacent to the 1–3.

H, 1st, 13. 7 right.

"I again used a system of guessing, limiting my guesses to 1, 2, or 3, since I do not recall having a 4 or 5 correct."

H, 1st, 16. 7 right.

"This time I tried to count the syllables in the word, and answer the corresponding number. This would account for the absence of 3, 4, 5."

Thus finally, on the 16th 20, H tried something new: but fatigue and flagging motivation made it unprofitable to continue for more than another 20 stimuli.

One striking feature in the records of the five Ss. who did learn to classify words according to the number of vowels is the suddenness of the learning apparent in the quantitative records (Table XIV). We find here a confirmation of the *a priori* assumption by Thorndike and Rock (21), that awareness would be marked by a sudden rise in score. It is, in this case, where the scores represent learning of a new and easily applied principle, rather than practice of a long-standing habit operating subject to many interfering habits.

Let us begin with E, the one S. whose scores do not show a sudden rise. E did this experiment as her 5th, and the effect of the earlier experiments is apparent in her introspections. The introspection

TABLE XIV[a]

NUMBER RIGHT, CLASSIFICATION BY NUMBER OF VOWELS, LIST IV

20 Word Units	*Ss.*						
	B	*C*	*D*	*E*	*F*	*H*	*H*
1	*6*	7	6	4	7	3	8
2	8	2	3	6	9	4	
3	3	8	5	*4*	*2*	3	
4	4	7	6	6	*9**	4	
5	*16**	6	8	5	20	4	
6	20	6	2	6		7	
7		6	5	10		5	
8		4	*6*	4		2	
9		5	*19**	7		2	
10		*5*		*13*		7	
11		*13**		14		5	
12		18		*9*		4	
13		18		*14**		7	
14		18		18		7	
15		*19*				5	
16		20				7	

[a] *Cf.* Note a, Table VIII.

from her tenth 20 gives a partial explanation of the gradual quantitative improvement.

E, 5th, 1. 4 right.

"I immediately began to classify the words under parts of speech, and place them under numbers representing those parts. I am not sure as yet what type word belongs under each number, but I do know that they are placed differently than they were in the preceding number experiment."

E, 5th, 3. 4 right.

"I have changed my procedure this time. I am basing my grouping on the number of letters in a word rather than a part of speech. However, I am not sure that this is correct."

Once a S. begins to count letters, we may consider that a partial solution has been made. From this point on E's solution is marked by a varied approach, by recurrence of the idea of parts of speech, by the relative complexity of the hypotheses tried, and by the logically inadequate verification given them.

E, 5th, 5. 5 right.

"I began this time by placing the word according to the number of letters, and whether these letters were odd or an even number. This has not worked out either."

E, 5th, 6. 6 right.

"This time I tried to place the word by placing it with the number which was the highest divisor of the number of its letters. This did not work. Then I went back to parts of speech again, but I am still unable to solve it."

This marked the end of one sitting. By an error which probably does not affect the results, the second sitting was begun with the same 20 words which had ended the first. The interval between sittings was four days. The numbering is as though the regular order had been followed.

E, 5th, 7. 10 right.

"I experimented with parts of speech again. This time I not only considered the verb or noun; but whether it was an active or passive verb, and whether the noun was a person, place or thing. I don't know whether these things have anything to do with solving the problem because I am still . . . experimenting with them."

After another 40 responses E began to consider the number of syllables; this did not bring immediate success, so the system was modified as reported in her next introspection.

E, 5th, 10. 13 right.

"I have continued with the same theory of syllables. I am not sure as yet of any definite classification, but I think that words of one syllable that end in a consonant belong with #1, words of two syllables under #2, words of three syllables under #3. However, I do not know where to place one syllable words ending in a vowel. I am still not sure that any of this theory is correct."

Near the end of this group of words E was ready to give up, especially when *1* was called wrong for *seem,* a monosyllable ending with a consonant. The complexity of the hypothesis retarded the solution; but this introspection, reporting awareness of vowels as such clearly marks a second step in learning. The same hypothesis was being tested through the next 40 responses, leading to the conclusion at the end of the 12th 20 (9 right), ". . . and something besides two syllables places words with #2." Solution came suddenly with the next 20.

E, 5th, 13. 14 right.

"This time, instead of syllables, I began to count vowels. So far this seems to work. Words containing one vowel with #1, etc."

C's gradual improvement in score through his last 120 responses represents his learning when to classify *y* as a vowel, and when as a consonant. The learning of the basic principle was delayed, but sudden.

C, 1st, 1. 7 right.

"When I answered *1* to the first stimulus *a* I thought that the number of letters in the word might give some clue to the correct answer. But this proved wrong. Later I tried to make some connection, such as *him–2* (to), but again the correct answer seemed a result of guessing."

Except for trying a serial order of responses, C maintained this approach for 140 responses until he was given negative instructions after the introspection below.

C, 1st, 7. 6 right.

"My correct answers always seemed *1,* which was my reaction to stimuli such as *what* or *something,*—namely, singular words. I also tried to place *2* (to) before verbs, such as *show, stop,* etc., but this did not work successfully. Therefore, outside of the number *1* my answers were merely cautious guessing."

After experimenting further with number sequences, C reports:

C, 1st, 10. 5 right.

"The five I answered correctly were results of saying *2* to words in which the vowel *a* appeared."

Inspection of the record shows that C had four such words correct, and that he also responded *silent–2.* On the other hand, he was wrong on *parent–3, shadow–4, angel–1, bark–2,* and *blame–5.* But adequately founded or not, the generalization brought vowels into the problem.

C, 1st, 11. 13 right.

"Thirteen correct answers have resulted from counting the number of vowels in the words, *i.e.,* two vowels meant *2.* I can't account for wrong answers."

The introspections do not show at what point in a group of 20 words a new hypothesis is tried. The responses show that C was apparently following the earlier hypothesis, assigning *2* to the letter *a,* through the first eight responses. He remarked "that dashed me," when told that *dash–2* was wrong. The remaining 12 responses were right with the exception of *Henry–1.* In other words, as soon as C tried this principle, he applied it as well as he knew how: the eight errors in the last 112 responses all involved the classification of *y.*

B's reports are marked by early awareness of vowels, with a correspondingly early decision that they were not involved. Otherwise, there is little of interest until the sudden return to a consideration of vowels, except the marked effects of the parts of speech and rhythm experiments, done just previously.

B, 4th, 1. 6 right.

"I tried out vowels, using the first vowel as an index, and numbering them a—1, e—2, i—3, o—4, u—5. This colored my mind for the first series, even though I knew it wasn't the system after about the first ten words. I am trying to recall responses, and number the different parts of speech, but can't remember many. I think *a* was *1, feat–2,* which would make 1—articles and 2—nouns . . ."

B, 4th, 5. 16 right.

"I decided that I was paying too much attention to factors that didn't seem to be yielding results. I had tried to classify vowels before, and this time I decided to count them—with apparent success."

The problem in the Vowels Experiment was the only one in the whole series which D solved. His introspections were meagre, and all pointed to the same approach: the analysis of spelling. On the basis of the first 100 responses he discovered that "the first letter seems to be of no importance," (4th 20, 6 right), and that words with *hi* are #1 (5th 20, 8 right), generalizing apparently from *ship–1* and *this–1*.

D, 2nd, 6. 2 right.

"Trying all combinations of the letters to see if they relate, but so far no luck. I have not the vaguest idea. I thought a double letter might have some importance, but if it has, I can't find it."

After the 8th 20 (6 right) he was thoroughly discouraged, but said, "I have an idea; if that doesn't work in the first few words, I'll never get it." It did, and after the fifth word in the next 20 he said, "Number of vowels?"

D, 2nd, 9. 19 right.

"Suddenly, I thought to count the vowels. This worked, but I was wrong for *only* which I don't understand; *y* is a liquid, but not a vowel to me."

F's introspections, in this as in other experiments, were long and detailed. They are interesting particularly as they show that a person whose approach to this problem was reasoned and systematic, learned in the same way as the others. The first step was attention to vowels; the second was the sudden insight which caused him to count them. F had previously done the parts of speech and speed experiments, solving both problems.

F, 3rd, 1. 7 right.

"My original plan was to repeat No. 1 for each word, with the object in mind of later correlating those words which were right. This led to the first two words, *a* and *am,* being right. However, I was soon diverted from my original plan by the recognition of an alphabetical sequence in the initial letters of the words. Attempts to develop a system from this were abortive. . . . I shall revert to my original plan."

In the first 20, 10 of F's responses were #1; in the second, 19 were #2; in the third, 19 were #3.

F, 3rd, 3. 2 right.

"Using 3 in all but the first word, only two words were right, *became* and *several.* This pretty well eliminated the possibility of a system based on alphabetical sequence. . . .

"I shall return to a hazy observation which I recall from the first list, but which I did not note, in my enthusiasm for developing a system on alphabetical order. This observation had something to do with the vowel sound appearing in the word. Since in some words more than one vowel appears, I shall note only the first. Some weight is lent to this possibility by the fact that there are *five* of these,—a, e, i, o, u. In light of present results, *a* is #1, *e* is #3. The right words in list 2 I have forgotten (words right for 2), but since *strong* is wrong for #2, in the last list, *o* is evidently not 2."

F, 3rd, 4. 9 right.

"Above possibilities were discounted within the first ten words. After that, while turning over other possibilities in my mind, another possibility connected with vowels occurred to me: namely, that the number corresponds to the number of vowels in the word. All evidence which I recall points to this being valid. The possibility occurred to me so late in the list that I did not have the opportunity to apply it beyond the last word, *fierce,* which was correct for 3."

F's memory was at fault here; the last three words were *example, fierce,* and *feeling,* all of which he had correct with responses of *3.*

F, 3rd, 5. 20 right.

"Added observation to above: insight was sudden,—mainly directed by the feeling that a system based on a e i o u was probable because there are 5 letters." (Numbers in the code.)

Once again we see that if the system underlying the assignment of rights is clearcut, and meets no interference from previous habits of the S., awareness of the principle brings an immediate jump in score.

The Frequency Experiment

Data from the Frequency Experiment are presented in Tables XV and XVI, showing respectively the number right and the deviation scores by successive 20's. This was, from the point of view of the Ss., probably the least satisfactory experiment of the series, since none of them reached a solution. From the point of view of the experimenter, by contrast, it was in many respects the most useful. In the first place, it set a limit; and with learning, in much the same way as with competition in the high jump for example, although skill is stated in terms of the most difficult level passed, this level is defined best by the first failure. Second, the two scorings possible in the Frequency Experiment—by number right and by deviation—permit a finer measure of learning than is possible in the other experiments. Third, the fact that the stimulus list for this experiment was the most carefully controlled of the five lists used, means that the essentially negative results acquire meaning as they are compared with the results from experiments using stimulus lists of looser construction.

TABLE XV[a]

NUMBER RIGHT, CLASSIFICATION BY FREQUENCY, LIST V

20 Word Units	Ss.					
	B	*C*	*D*	*E*	*F*	*G*
1	7	3	3	4	2	7
2	5	4	7	7	5	5
3	5	3	6	*8*	3	4
4	8	6	6	*5*	4	5
5	9	8	8	*3*	2	5
6	4	4	6	8	4	6
7	5	4	9	2	4	8
8	1	8	4	9	6	3
9	5	7	7	9		3
10	5	5	5	8		7
11	5	9	2	3		5
12	4	4	4	8		1
13	3	6	3			4
14	7	7	6			4
15	2	3	5			4
16	6	7	3			4

[a] *Cf.* Note a, Table VIII.

One of the Ss. paid the experimenter an unintended compliment after he had finished the full series of the experiments by saying that the stimulus list of this one was different—and much more difficult—than

TABLE XVI[a]

DEVIATION SCORES,[b] CLASSIFICATION BY FREQUENCY, LIST V

20 Word Units	Ss.					
	B	*C*	*D*	*E*	*F*	*G*
1	0.9	1.5	1.25	1.15	1.4	1.3
2	1.05	1.0	0.95	0.85	1.05	0.9
3	1.0	1.15	0.9	*0.7*	1.6	1.15
4	0.9	1.15	1.0	*1.1*	1.75	1.3
5	0.95	1.0	0.75	1.2	1.25	1.2
6	1.65	1.1	1.2	1.0	1.1	1.1
7	1.3	1.35	0.85	1.35	1.05	1.2
8	1.7	0.9	1.15	0.65	1.15	1.25
9	1.05	1.0	0.9	0.75		1.35
10	1.3	1.1	1.15	0.95		1.1
11	1.25	0.9	1.25	1.05		1.1
12	1.45	1.1	1.1	0.95		1.6
13	1.55	1.4	1.35			1.2
14	1.2	1.05	1.1			1.3
15	1.35	1.35	1.3			1.3
16	1.15	0.9	1.0			1.15

[a] *Cf.* Note, a, Table XV.

[b] The chance expectation is a score of 1.25; perfect performance would give a 0 score.

the others, because it provided no leads. To the extent that his observation was correct, the experiment is a good one: if we are to get experimental evidence on learning by using meaningful words as stimuli, the stimulus list should be so arranged that the words will not evoke any one response except as the Ss. have learned.

We shall begin with the four Ss. who did not seem even to approach the solution of the problem, reserving until the last the two Ss., one of whom was pointed in the right direction but turned away, and the other of whom almost solved the problem. It may be significant that both of these latter Ss. stopped well short of the minimum allowance of 320 stimulus words, both of them quite despairing of further progress.

G, 1st, 1. 7 right. dv. score 1.3.

"There is no correlation between the number of syllables per word, and the number reported as correct. In the technical terms, such as *benzine* (3) and *ammonia* (2), there is no number occurring in their chemical formulae corresponding to the number in the correct answer. Obvious relations, such as 1 for *monotony* and 2 for *doubly,* are also not the key. . . ."

In the next few lists G takes up and discards hypotheses based on number series, number of repeated letters, number of consonants or vowels in sequence, double letters, number of vowels, alphabetical arrangement, meaning (stated without elaboration), odd and even numbers, etc, etc. Negative instructions were given after the 11th and 15th 20's, with respect to analysis according to spelling, or number sequences. After the 16th 20 he can merely say (4 right, dv. score 1.15): "The words apparently cannot be classed according to such common divisions as *earth, air, water, fire, animal, vegetable, mineral,* etc."

Although G did not learn, his work on this experiment was marked by a broader, and essentially better, approach than he showed in his later performance on the rhythm experiment, which was marked by perseveration of a single idea.

C had this experiment as his third, after solving the problems in the vowels and the rhythm experiments; nevertheless his approach was essentially similar to that of G, who had it as his first. C had two sittings, the break coming after the 4th 20; the interval between sittings was 5 days.

C, 3rd, 1. 3 right. dv. score 1.5.

"The number of syllables in the words has nothing to do with the response number; neither has the number of vowels in the word. *3* was O.K. for *guillotine.*"

From here on C tried out a variety of possibilities: ordinal positions in the word of the syllables containing a given vowel, or of the letter carrying the accent; number sequences; the number of different vowels; number of consonants occurring more than once; and the like. After the 12th 20 negative instructions were given with respect to analysis of spelling. Two of the remaining introspections are worth citing, the first as illustrative of the complexity of hypothesis tried, and the second as calling for some explanation—which the experimenter is unable to provide.

C, 3rd, 13. 6 right. dv. score 1.4.

"It is useless to analyze tongue movements. Saying *2* for *overalls* was right (2 because tongue moves up on the second syllable) and *1* for *product* was right, but I accidentally got *3* for *slouch* correct, and that spoils the system."

C, 3rd, 15. 3 right. dv. score 1.35.

"On this list I only hit three right because I guessed, saying the number almost immediately after I heard the word. What impresses me is that no matter what system I use, even if it is wrong, at least I get better results than by guesswork. This phenomenon is a mystery to me."

The outstanding feature of B's performance, who did this experiment as her fifth, is the amount of interference shown as a result of the four previous solutions.

B, 5th, 1. 7 right. dv. score .9.

"I tried the different methods I had used in the previous experiments, attempting to count first the number of different consonants, then the number of different vowels, and finally the number of syllables. I paid no attention to anything else about the word. These attempts were, on the whole, not successful—which means that I must try something else next time."

Essentially this approach continued through the entire 320 responses, in spite of negative instructions.

B, 5th, 4. 8 right. dv. score .95.

"*Insect* was #1 and right. In that word I picked out the *ct* that go together. I did that in several other words, looking for the vowels or the consonants which are used together. Next time I shall try: 1—consonant blend; 2—double consonant; 3—double vowel; 4—?"

B, 5th, 8. 1 right. dv. score 1.7.

"Just confused—no plan at all. In spite of suggestion I still find myself analyzing sounds and spelling."

B, 5th, 15. 2 right. dv. score 1.35.

"In the other experiments I usually knew when I was wrong after the first few lists of words. In this I have absolutely no feeling of being right or wrong."

D tried to work out number sequences, and tried various count-

ing devices—syllables, letters, consonants—some with the added complexity of dividing the sums by two or three. His introspections contribute nothing new of any significance.

F's record is of interest chiefly in giving some indication of how a wrong hypothesis is formed. He had previously solved the parts of speech, speed, and vowel problems, and had reached a partial solution in the rhythm experiment.

F, 5th, 1. 2 right. dv. score 1.4.

"I had no *a priori* method of approach, other than simply calling out the same number for each word. The nature of the list soon led me to suspect a system based on the etymology of the words, for example: 1 from the Latin, 2 from Greek, 3 from French, 4 Anglo-Saxon. Chance numbers gave only two correct, from which no generalizations are yet possible. A further attempt will be made to develop this system. A possibility which occurred to me through the latter half was that the words were in some way connected in meaning to words previously given. This will be kept in mind while working on the other possibility."

This last possibility is not clear to the experimenter; the reference is probably to relations in meaning within this stimulus list, rather than with words used in the other experiments.

F, 5th, 2. 5 right. dv. score 1.05.

"Great difficulty was encountered in working through the above system, due to my ignorance of etymology. Right was #4 for *pismire* and *bruin*. *Chancel* was also right for #4 on the previous list. It is quite possible that these words for #4 are related in being Anglo-Saxon in origin, but I certainly am not positive. This method will be continued, working on #4 only, in order to accumulate evidence. A system of repeating the same number is one which I have repeatedly intended to use on previous problems, but from which I have deviated with poorer results than if I had not."

"The other possibility, that of a direct connection, did not seem so evident on this list."

F, 5th, 3. 3 right. dv. score 1.6.

"*Morion, pointer,* and *speedily* were right for #4. *Chancel, pismire,* and *bruin* were previously correct for #4. Possibly because *morion, pismire,* and *chancel* are nonsense to me, I feel that they are old English, and hence more than probably Anglo-Saxon in origin. However, this is certainly not even probable. . . . in light of the other three words. It is still barely possible that this system pertains. . . .

"The other possibility was lent further evidence by my vague perception of a connection among some of the words. One which I remember is *sanitary,* to which several of the words seemed related in meaning. Evidence gathered from #4 right words does not support this. On the other hand it is quite possible that . . . a different system may operate for each number. . . ."

In the next introspection F suggests that #4 may be the class in

which "all other" words are put. It is apparent that by being aware not only of the meanings of the words,—the other Ss. had been attentive largely to spelling or to serial position,—but aware also of rarity of meaning, F had the elements of the solution. But he had first been aware of etymology; and the new aspect, rarity or unfamiliarity, was absorbed into, and interpreted in terms of, the previously existing one.

Through the remainder of his work on this experiment F followed a thoroughly logical course, listing seven possible systems of classification "based on word structure," and five "based on use," in addition to etymology and certain other possibilities. Responses were rapid; those to the first 40 words were well distributed among the four numbers, 39 of the second 40 responses were #4, all of the third 40 were #3, and all of the next 20 were #2. The eighth, and for him, the final, 20 responses were again well distributed. At this point, having spent just short of two hours on the problem, the bulk of it given to considering and writing introspections, fatigue and loss of motivation made it unwise to urge him further.

The nearest approach to a solution of the problem in the frequency experiment was by E. In no case did she get as many as 10 right out of 20 responses; but 7 of her 12 dv. scores were 1.0 or better, and three of them were .75 or better. The informed Ss. in the brief control experiment, *cf.* p. 33, gave average dv. scores ranging from .45 to .92, with the median of .63, and only 6 individual scores of 1.00 or more; E was thus fairly close to a good quantitative performance. E missed the correct principle in an important but very subtle way. But these findings can be shown best in the introspections.

E, 2nd, 1. 4 right. dv. score 1.15.

"After this first group of twenty words I haven't the least conception of what makes a word right or wrong. A good number of my responses were mere guesses, while others actually suggested themselves by the stimulus."

E, 2nd, 2. 7 right. dv. score .85.

"I am still in the process of discovering which are right and which are wrong answers. It is more likely that an answer will be wrong in this experiment than the one preceding it, for it offers more opportunity for choice than did the former one. This is the case, I believe, because one is not likely to have made number associations with a word before this time. . . . My associations thus far have been mostly on the basis that the larger word suggests the larger number."

The preceding experiment in this case was the rhythm experiment, which E had failed. This statement, even from a relatively

unsophisticated S., is evidence that in the so-called free association response, the stimulus actually controls the response for any S. who will let it do so. In this connection it is unimportant that E had failed to derive the rhythm principle. In this experiment she had never more than three wrong responses possible—she had always one chance in four of being right—but she believed herself more likely to be wrong here than under conditions permitting her to respond with any words or word in the language, only a few of which would be right. But while a multitude of answers might be made without apparently violating the instructions, only a few are psychologically possible to stimuli of as frequent use as those in the rhythm experiment.

In the next statement we see the effect of balancing the words used in the frequency experiment as to length. Having begun by assigning the larger numbers to the longer words, E now shifts the criterion slightly.

E, 2nd, 3. 8 right. dv. score .7.

"My numerical associations seemed not only to be based upon the actual physical size of the word, but the meaning that it has, or the object or subject it suggests."

This is still somewhat vague in statement.

E, 2nd, 4. 5 right. dv. score 1.1.

"The associations that I made in this group were based mainly on the importance of the meaning of the word to me. For example, a word like *thymus* (3, W), which suggests an important gland to me, would have one of the larger numbers associated with it, that is 3 or 4. . . ."

E, 2nd, 5. 3 right. dv. score 1.2.

"With this group of words I tried to experiment as to the correct answer. Instead of making a personal association, I tried to make an association that I thought might be the correct one. I gave all common nouns like *onion, biscuit,* etc., the number 1. Other words, as they became less common and of more importance, higher numerals."

E has thus made a statement which is almost exactly correct for the frequency problem, except for the addition of importance as part of the criterion. It is interesting that as she arrived gradually at this statement, her scores got worse. The "importance" of a word, or of the idea it stands for, is not irrelevant in the word's frequency of use, but E was trying to apply two criteria which were at least partially contradictory. *Sheep* (1) is in some ways a more important word than the related ones, *broadcloth* and *zoology,* both rated 3.

E, 2nd, 6. 8 right. dv. score 1.

"In this group I again gave the common words a rating of 1 or 2, and

definitely tried to give most of the words suggesting abstract things, like *imagine* (3) and *reverent* (3) the rating of 3 or 4.''

But both *imagine* and *reverent* are properly classified as 1. In the introspections above E shows awareness of the correct principle, plus the incorrect notion that as applied to words, the opposite of *common* is *important* or *abstract,* rather than *uncommon* or *rare.* She continues in much the same vein, but becomes confused and uncertain, leading to the report after the 11th 20, ''constantly, any method that I have devised is being broken down.'' Motivation was now such that it would have been necessary to discontinue the experiment. The experimenter therefore gave the positive assistance: ''You have been very close to the correct system.''

E, 2nd, 12. 8 right. dv. score .95.

''On the basis of the above statement, I went back to my former method of classifying the commonplace words such as *carpenter* (1, R), under number one, etc. While placing a word under a certain classification or number I often debated whether a word should be 1 or 2, or whether it should be 3 or 4. However, I rarely had to debate (the choice between 1 and 4, or 2 and 3). In other words, I made two different classifications, 1 and 3; with the numbers 2 and 4 acting in pairs with 1 and 3.''

In the above statement ''commonplace'' may mean either ''of frequent use,'' or ''of easy meaning.'' In the light of E's earlier introspections, both meanings may be present, and we cannot properly say that she was clearly aware of the correct principle. But the principle she was aware of was at worst only slightly different from the correct one; she had arrived at this awareness through gradual steps; and she had done so in spite of the fact that in each set of 20 responses, more than half were wrong. In some respects her performance was similar to C's in the speed experiment, who had awareness without learning, and who, after stating the correct principle without seeing its significance, got poorer scores as he searched for some other.

CHAPTER VI

DISCUSSION

The results have been presented in a good deal of detail, accompanied by interpretive comment. Such an arrangement seemed likely to make it easier for the reader to follow the author's interpretation and conclusions, by locating the latter adjacent to the facts to which they are referred. I believe that in every case the context distinguishes adequately between fact and opinion. What remains is largely a matter of summarizing and organizing scattered material. What do the results mean, especially in relation to the questions stated on page 5.

Although all adult Ss. at the college level have been accustomed on occasion to classify words in various ways, the classifications employed in the number code experiments are not matters of long habit. It is very much a matter of habit, however, to respond to words with associated words, and to do so within a time probably characteristic of the individual. One type of such associated response which we may expect to be thoroughly habitual is response according to the principle of the Sequence Experiment, by a word which normally follows the stimulus in speech and writing. The criterion for the Speed Experiment is arbitrary, well within the normal speed of speech, although for individual Ss. it may be rather more rapid than their normal reaction times under the experimental conditions used. The extent to which normal speech and writing meet the criterion used in the Rhythm Experiment, of having stimulus and response matched as to number of syllables and accent, is as yet undetermined, and this paper provides no evidence on the point. But there is reason to believe that rhythmical patterns are highly important in English usage, so that Ss. in these experiments would have already well established a set of rhythmical habits partly controlling their use of words. Whether such habits can be expected to make performance in this experiment easier or more difficult, no one is at present able to say.

It is probably unnecessary to labor the explanation further: all three of the verbal response experiments make heavy drafts on the previously formed habits of the Ss. If we are to expect learning without awareness in only one of our types of experiment, we should expect it in this first group rather than in the number code experiments. Here the Ss. can, if such learning does in fact take place, continue to respond habitually and without awareness, while their

performance becomes noticeably better. Under these conditions, what do we find?

Let us consider awareness first. Every S. who had the announcement, "Right" or "Wrong," made according to the sequence principle became aware of that principle. Every S. who had the announcement according to the speed principle was aware of that principle, although two Ss. who were aware *of* the solution, were not aware of it *as* a solution. Two of the Ss. in the Rhythm Experiment were fully aware of that principle; two others reached perfect performance without awareness. One of these latter Ss. was aware of part of the ruling principle, and both of them had their perfect performance by the device of repeating the stimulus words in their responses. The remaining two Ss. did not become aware of the correct principle, although one of them had used, while doing an earlier experiment, a hypothesis very close to the principle used in this one.

So much for the awareness reported by the Ss. Let us consider next the evidence of learning. When we do so, it is possible to dismiss at once the cases of all Ss. who were aware of the solutions as such; clearly, all these Ss. learned, and learned with awareness. There remain the two Ss. receiving announcement on the speed principle who stated the solution without recognizing it. One of these, C, almost certainly did not learn; responding to 200 words, he had 90 right in the first 100, and 77 in the 2nd. The other, D, showed some improvement in speed while responding to 640 words. There remain only four Ss. in the Rhythm Experiment. The two who got perfect performance by repeating the stimulus words require separate treatment: one of them, F, had clearly made a partial learning with awareness before he adopted this device; the other, G, made no clear progress toward learning after this device was forbidden. The remaining two Ss. in the Rhythm Experiment clearly did not learn.

Thus, using three different types of response, all of them to some extent habitual, and using Ss. who varied in the order in which they did these and the other experiments, careful study of the quantitative records reveals only one possible case of learning without awareness: that of one S. who responded in the Rhythm Experiment by repeating the stimuli, but could not apply the correct principle in other responses.

A similar survey of the number code experiments gives similar evidence as to awareness. In the parts of speech experiment four Ss. were aware of the correct principle, and gave quantitative scores indicating learning. Two were not aware of the principle, and clearly

did not learn, although one of them, C, was able to give improved scores from memory when the same stimuli were repeated. In the Vowels Experiment five Ss. were aware of the solution, and clearly learned; the sixth was not aware of it, and as clearly did not learn. In the Frequency Experiment none of the Ss. gave clear quantitative evidence of learning; one of them was partially aware of the correct principle.

Considering next the sucess of the Ss. in applying the principles of which they were aware, we find that the two types of experiments give contrasting results. All three of the verbal response experiments indicate that awareness of a rational principle does not necessarily bring immediate perfect performance in accordance with that principle; on the contrary, perfect performance was in every case delayed, and in some cases never reached. This merely confirms the work of Irwin and others (8), indicating that gradual quantitative improvement in learning is consistent with awareness of what is being learned. Further, the introspections from the verbal response experiments explain why the quantitative improvement is gradual: with instructions to respond with the first word which comes to mind, Ss. who attempt to follow instructions find that the stimulus sometimes forces a response which does not fit the principle they are also trying to observe. In the number code experiments, by contrast, we find that awareness of the correct principle underlying the responses brings a sudden improvement in quantitative scores. Thorndike and Rock (21) had some reason for their *a priori* assumption that the shape of the learning curve should be an index of awareness in rational learning. It is so in the Parts of Speech and Vowels Experiments reported here, where the principle used in scoring is not one which the Ss. have been practicing for years.

Stress must be laid on the difference between the association word and the number code experiments. In each group the Ss. began with free and random responses, and proceded as rapidly as they could to give rigidly controlled responses. They differed in the amount of expected influence from previous habit. Consider, for example, that responses of the following type, promptly given, would be scored correct in *all* of the association word experiments: *apple–jelly, hard–luck, beneath–the stars.* Consider further the influences which could bring such responses, and we see the strongest reason for supposing that the same factors in the S's. previous experience which make his response correct according to one principle, act to make it correct according to one or both of the others. The more rigidly controlled

numerical responses can become consistently right only through the operation of much different forces. The essential point here is that in the association word experiments the stronger pull of early habit is shown not only in early awareness and partial awareness, but also in the difficulty of obtaining a perfect score with full awareness. In brief, much of the improvement in the course of the association word experiments is probably due to the removal of accidental barriers and disturbances to the operation of habit patterns already well formed, and not to learning in the sense of the acquisition of new patterns.

In pursuing this interpretation further, it will be well to examine the meanings of the differentiating adjectives commonly applied to association word methods. Why are the associations revealed by a "free association" method called free? What is the nature of the control over associations which is exercised in a "controlled association?"

"Controlled" and "free" are capable of broad use in describing the association of words. They may be used to describe the experimental conditions,—the directions given the Ss. For example, directions to respond to a series of adjectives by their opposites, or to a series of nouns by their supraordinates, represent greater control than directions to respond with any word, and probably less control than directions to respond by translation to another language. This usage represents control by the experimenter, and the distinction between free and controlled is both convenient and clear. It is probably the commonest usage of the terms.

But they may be applied by extension to cover the success of the Ss. in meeting the requirements of the directions received. A S. directed to respond to adjectives by their opposites may occasionally or frequently respond by nouns to which those adjectives apply. To the extent that he does so, his responses are uncontrolled. Again, the distinction is an important one, and the usage is defensible, if it is clear.

Finally, again by extension, "free" and "controlled" may be applied to the associations commonly evoked by the stimulus words. *Nuk, autochthonous, salubrious, casual, black,*—such a series of adjectives varies widely in the amount of control which they exercise as stimuli over the associated responses. At the risk of confusion, let us attempt to put all three usages into a single illustrative sentence: "Under conditions of controlled association (E's directions to respond by opposites) the S. gives poorly controlled responses (names

few opposites) because the stimuli are uncontrolled (have acquired in his experience, few or no opposite meanings)."

"Controlled" with its opposite "free" may thus be applied to the method used, to the application of a given principle by the Ss., and to the stimuli as they affect such application.

As to method, the above experiments were all partly controlled: no specific principle of control was stated to the Ss., but they were to find one and apply it. Referring to the Ss., the degree of control is reflected in the quantitative scores. Although the least common usage, the most important for the purposes of this discussion is the control exercised by the stimulus words. This is of course closely related to the control by the S. which comes from awareness of a principle, and is reflected in his scores. Our interest is in the stimulus value of the word, in its relation to correct response, and most of all in the way the stimulus values of the words change in the course of learning.

The essential aspect of a word is its meaning; the essential factor in learning, as measured by the association word method, is change of meaning. No full discussion of meaning can be attempted here: for the purposes of this treatment we may consider the meaning of a word to be defined by the reaction produced when the word is given as a stimulus. The meaning is not a property of the word, in the sense that irritability is a property of protoplasm, or ordered arrangement a property of a watch. It is a result of a complex situation: the auditory stimulus, the whole previous experience of the S., and the experimental situation. When we say that a word has much meaning we are saying that from the Ss. to whom it is applied as a stimulus it can evoke many responses, or that the responses it evokes will be strong, fixed, and certain.

A nonsense word, *nuk,* for example, has little meaning except for the S. who has been trained to respond to it with *lan;* for that S. it has a strong and precise meaning. Some meaningful words, such as *autochthonous, salubrious,* and *casual,* are, in fact, relatively meaningless; the experience of most Ss. includes only infrequent or limited contact with them. But again, for those Ss. who have had contact with these words the meanings are strong and precise: they have been met in few contexts, and their applications are correspondingly limited. A word such as *black* is highly meaningful, since frequent and varied use of it makes many responses possible. But the greater number of possible responses reduces the probability that any one of them will occur.

In each example just cited the meaning has been considered from the point of view of the previous experience of the Ss. To the extent that we can hold this factor constant, we can expect the meanings, *i.e.*, the responses, to vary with the experimental situation. Now there are three ways of holding the meaning constant so far as it depends on the previous experience of the Ss. We may reduce that meaning to a minimum, by using nonsense words. We may make it strong and specific by using stimuli which the Ss. have experienced, often but in few contexts. Or we may make it rich and generalized by using stimuli which the Ss. have encountered frequently and in many contexts. Similarly, the problem set may call for specific or generalized responses.

Nonsense words as stimuli have much to recommend them: the findings from such experiments are clearcut and definite. But what they gain in precision they lose in other ways, notably in the application of the results to other situations. The considerable attention given to the stimulus lists in these problems represents an attempt to approach the precise control of the stimulus value which has hitherto been possible only with nonsense stimuli, in an experimental procedure which permits easier generalizations to the ordinary learning situations, the control of which is the ultimate justification for experimental work in learning. The problem is a large one, and the work reported above merely approaches it: the most that can be claimed on this score is that it is possible to control the meanings of stimuli for association word experiments, to the extent that such meanings depend on either the frequency of use, the length, or the grammatical classification of the words. Even this much is claimed only tentatively, and the author is planning to do further work along the lines indicated in the section on stimulus lists.

The full series of experiments proved extraordinarily difficult for most of the Ss., in spite of the fact that the basic problems were not especially complex,—not nearly so complex, for example, as many of the hypotheses used in trying to solve them. In fact, the selection of these particular problems had followed the rejection of several others, which informal application had proved too difficult. The introspections already cited show some of the primarily intellectual difficulties which the Ss. faced. It is not possible to give as clear expression to the emotional difficulties, which had an unmeasured effect on the number and variety of the hypotheses tried, and on the system used in testing them. In some cases, as already reported, emotional factors prompted discontinuance of an experiment. It was

found, also, that the announcement of *right* could on occasion be a serious annoyance to a S.

With respect to these last items—the number and variety of the hypotheses tried, and the methods used in testing them—there is little difference between the findings from the verbal response and number code experiments. In these directions the most striking thing obtained from analysis of the introspections is the evidence of strong perseverative tendencies in the approach to learning. These were manifested in three ways. Ss. would carry forward into a later problem the hypotheses used in an earlier one; this was done even by Ss. who had solved the earlier problems, and might reasonably have excluded their solutions *a priori*. Perseveration was shown also in the persistence of irrelevant hypotheses which were not inconsistent with the correct one. Finally, it was shown in the return to wrong hypotheses after specific negative instructions.

In connection with such perseveration it should be noted that fully logical verifications of the hypotheses were seldom attempted, and that in general the more fully a S. tested out a wrong hypothesis, the more likely he was not to arrive at a correct one.

Conversely, good learning was marked by variety of hypothesis. The findings on this point are subsidiary to the main purpose of the investigation, and are only suggestive; but they are important. In any of these six problems, as it comes to the Ss., there is an almost indefinite number of possible solutions, yet solutions were reached, and within times which to the philosophic eye were comparatively short. Regardless of what the quantitative scores indicate about suddenness or gradualness, the introspections show that the difficult learning was gradual. The S. first became aware: "Some of these words are nouns," later that "Nouns are #1." He learned first to match words by number of syllables, then by accent. His attention was first on the fact that usual responses were right, then either that language sequence or high speed can be noticed in his usual responses. He first notices that a word has letters, or vowels, then that the number of vowels is the critical point. The poor learning of the perseverative Ss., and the solutions reached by those who varied their hypotheses, even though they did not test them thoroughly, both depend on the necessity of locating the solution as within a given field.

CHAPTER VII

CONCLUSIONS

Using six different adaptations of the association word method, with introspections, it was found:

1. That, contrary to the conclusions offered by Thorndike and Rock, learning of an intellectual kind does not take place without awareness of what is being learned.

2. That the degree to which the learned response is a new one in the learner's experience determines whether awarenss of the correct principle brings an abrupt improvement in score.

3. That gradual improvement in controlled responses occurs when the controlling principle is an habitual one. In such cases conflicting habitual responses are effective in preventing the preferred response.

4. That grammatical classification, length, and frequency can be brought under fair control in preparing lists of meaningful words for experimental purposes.

5. That perseveration in inductive learning is marked in the carrying of familiar hypotheses into new situations, in the retention of non-essential hypotheses, and in the persistence of wrong hypotheses in spite of negative instruction.

6. That good learning is marked by abandonment of wrong hypotheses before they have received a fully logical disproof.

7. That good learning is marked by variety of hypothesis.

8. That solutions, even in cases with sudden increase in score, are gradual.

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